APRIL 1997

RESEARCH AND RECOVERY OF SNAKE RIVER SOCKEYE SALMON

Annual Report 1995 - 1996

BONNEVILLE
POWER ADMINISTRATION

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

For additional copies of this report, write to:

Bonneville Power Administration
Public Information Center - CKPS-1
P.O. Box 3621
Portland, OR 97208

Please include title, author, and DOE/BP number from the back cover in the request.

RESEARCH AND RECOVERY OF SNAKE RIVER SOCKEYE SALMON

ANNUAL PROGRESS REPORT
APRIL 1, 1995 - APRIL 1, 1996

Prepared by:

Paul A. Kline, Senior Fishery Research Biologist

And

James A. Lamansky Jr., Fishery Technician

Idaho Department of Fish and Game
Nampa, Idaho 83686

Prepared for:

U. S. Department of Energy
Bonneville Power Administration
Environment, Fish and Wildlife
P.O. Box 3621
Portland, OR 97208-3621

IDFG 97-5
Project Number 91-72
Contract Number DE-B179-91BP21065

April 1997

TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

LIST OF TABLES (Cont.)

LIST OF FIGURES

LIST OF APPENDICES

LIST OF APPENDICES (Cont.)

EXECUTIVE SUMMARY

On November 20, 1991, the National Marine Fisheries Service listed Snake River sockeye salmon *Oncorhynchus nerka* as endangered under the Endangered Species Act of 1973. In 1991, the Shoshone-Bannock Tribes and the Idaho Department of Fish and Game initiated the Snake River Sockeye Salmon Sawtooth Valley Project to conserve and rebuild populations in Idaho.

The first planting of hatchery-produced juvenile sockeye salmon from a captive broodstock occurred in 1994 with the release of 14,119 fish to Redfish Lake. Two release strategies were used with four broodstock lineages represented. In 1995, 95,411 hatchery produced juvenile sockeye salmon were planted to Stanley Basin waters, including the release of additional broodstock lineage groups and release strategies in Redfish Lake, a yearling smolt release to Redfish Lake Creek, and a direct release to Pettit Lake.

September estimates of total 0. *nerka* abundance and density in Redfish Lake have increased by almost 200% since 1990. During September 1995, we estimated total *O. nerka* abundance and density at 61,646 fish and 150 fish/hectare, respectively. Alturas Lake *O. nerka* total population, density, and biomass estimates (September) increased by approximately 300% over 1994 levels. Population and density estimates have declined sharply, however, since trawling was initiated on Alturas Lake in 1990. During September 1995, total population and density were estimated at 23,061 fish and 109 fish/hectare, respectively. From September 1994 to September 1995, total population and density estimates of Pettit Lake *O. nerka* increased from 14,743 fish and 128 fish/hectare to 59,002 fish and 513 fish/hectare, respectively. For this same time period, Stanley Lake O. *nerka* population and density estimates declined from 2,694 fish and 37 fish/hectare to 1,021 fish and 13 fish/hectare, respectively.

We trapped a total of 109 wild and 219 hatchery-produced sockeye salmon outmigrants at the Redfish Lake Creek trap in 1995. Based on 1995 trapping efficiencies, total outmigration or run size was estimated at 357 wild and 823 hatchery-produced juveniles. Broodstock progeny from the August 3, 1994 Redfish Lake net pen release strategy produced significantly greater interrogations at the Redfish Lake Creek trap than progeny from the November 23, 1994 direct release to Redfish Lake strategy. At mainstem Snake and Columbia river dams, no significant difference in the number of cumulative, unique interrogations was observed for these two release strategy groups. Wild outmigrants produced a significantly greater cumulative, unique interrogation rate than sockeye salmon from any of the broodstock program release strategies employed in 1994 and 1995. With the exception of the wild outmigrants, progeny from the April 21, 1995 direct to Redfish Lake Creek release strategy (age 1 + smolts) produced significantly greater detections than sockeye salmon from any of the broodstock program release strategies employed in 1994 and 1995. Seven *O. nerka* outmigrants were captured at the Sawtooth Fish Hatchery trap in 1995. Based on seasonal trap efficiency, this expands to an estimated 135 total outmigrants.

In 1995, we located 5 of 11 adult sockeye salmon (fitted with ultrasonic transmitters) released into Redfish Lake in 1994 and still active at the termination of 1994 tracking efforts. No movement was noted for any of the five audible transmitters, indicating fish had not successfully survived the winter (assuming transmitters were not shed).

Trend sections were established on tributaries of Redfish and Alturas lakes in 1995 to monitor bull trout *Salvelinus confluentus* spawning escapement. The objective of this effort was to evaluate predator production in relation to sockeye salmon recovery options. We identified eight redds and two pair of adult spawners in the Alturas Lake system. Three redds and five adults were recorded in the Redfish Lake system.

We used otolith microchemistry to confirm the life history of Redfish Lake sockeye salmon with known lineage to female anadromous and kokanee *O. nerka kennerlyi* parents. Mean strontium/calcium ratios (Sr/Ca) in otolith nuclei from progeny of the one female sockeye salmon that returned to Redfish Lake Creek in 1994 showed patterns consistent with known anadromous life history (Sr/Ca ratio > 0.0014). Mean Sr/Ca ratios in otolith nuclei from progeny of the two anadromous adult female sockeye salmon that returned in 1993 produced similar results (19 of 20 samples produced Sr/Ca ratios >0.0014). Mean Sr/Ca ratios in otolith nuclei of male kokanee collected in Fishhook Creek in 1995 were also consistent with our expectations (all samples <0.0008).

Sockeye salmon recovery in Redfish Lake may depend on reducing kokanee biomass. In 1995, the National Marine Fisheries Service extended permission to the Idaho Department of Fish and Game to re-open Redfish Lake kokanee harvest as one means of achieving this goal. Data generated from a creel survey indicated anglers fished an estimated 2,554 hours during the 17-day season to catch 440 kokanee. Three hundred six of these fish were harvested, contributing to the goal by reducing 1995 kokanee spawner escapement. The overall catch rate for kokanee was 0.15 fish/h (0.11 fish/h harvested, 0.04 fish/h released).

Authors:

Paul A. Kline
Senior Fishery Research Biologist

James A. Lamansky, Jr.
Fishery Technician

INTRODUCTION

Numbers of Snake River sockeye salmon *Oncorhynchus nerka* have declined dramatically in recent years. In Idaho, only the lakes of the upper Salmon River (Stanley Basin) remain as potential sources of production. Historically, five Stanley Basin lakes (Redfish, Alturas, Pettit, Stanley, and Yellowbelly) supported sockeye salmon (Bjornn et al. 1968; Chapman et al. 1990). Currently, only Redfish Lake receives a remnant anadromous run.

On April 2, 1990, the National Marine Fisheries Service (NMFS) received a petition from the Shoshone-Bannock Tribes (SBT) to list Snake River sockeye salmon as endangered under the Endangered Species Act (ESA) of 1973. On November 20, 1991, NMFS declared Snake River sockeye salmon endangered. Section 4(f) of the ESA requires the development and implementation of a recovery plan for listed species. At the time of this writing, a seven member team (appointed by NMFS) is in the process of preparing the final draft of this document.

The Idaho Department of Fish and Game (IDFG), as part of their 1992 through 1996 management plan, is charged with the responsibility of reestablishing sockeye salmon runs to historic areas, with emphasis placed on efforts to utilize Stanley Basin sockeye salmon and kokanee *O. nerka kennerlyi* resources (IDFG 1992). In 1991, the SBT along with the IDFG initiated the Snake River Sockeye Salmon Sawtooth Valley Project (Sawtooth Valley Project) with funding from the Bonneville Power Administration (BPA). The goal of this program is to conserve and rebuild Snake River sockeye salmon populations in Idaho. Coordination of this effort is carried out under the guidance of the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC); a team of biologists representing the agencies involved in the recovery and management of Snake River sockeye salmon. Under the ESA, NMFS Permit Nos. 795, 823, and 844 authorize IDFG to conduct scientific research on listed Snake River salmon.

IDFG participation in the Sawtooth Valley Project falls under two general areas of effort: 1) the sockeye salmon captive broodstock program; and 2) Stanley Basin fisheries research. While objectives and tasks from both components overlap and contribute to achieving the same State goals, work directly related to the captive broodstock program will appear under separate cover. In this report we present fisheries research information collected between April 1, 1995 and April 1, 1996. Specific activities covered include: Stanley Basin lake *O. nerka* population monitoring, monitoring the fishery on Redfish Lake, monitoring the smolt outmigration from Redfish and Alturas lakes, telemetry studies on Redfish Lake, Redfish and Alturas lake predator investigations, and otolith microchemistry analysis of wild and broodstock sockeye salmon.

The ultimate goal of IDFG sockeye salmon research is to reestablish sockeye salmon runs to Stanley Basin waters and provide for the utilization of sockeye salmon and kokanee resources. The immediate project goal is to maintain Stanley Basin sockeye salmon, through captive broodstock supplementation, and avoid species extinction.

OBJECTIVES

1. To describe *O. nerka* population characteristics in four Stanley Basin lakes in relation to carrying capacity concerns, supplementation efforts, and species recovery.

2. To determine the contribution wild and hatchery-produced sockeye salmon make toward recovery efforts.

3. To provide this information in a form usable to the captive broodstock program.

4. To determine predator effects on sockeye salmon in relation to recovery options.

5. To refine our ability to discern the origin of wild and broodstock sockeye salmon to provide maximum flexibility in their utilization within the broodstock program.

STUDY AREA

The Stanley Basin lakes are located within the Sawtooth National Recreation Area (SNRA) (Figure 1). Basin lakes are glacial-carved and receive runoff from the east side of the Sawtooth and Smoky mountains. Physical and morphometric data for Redfish, Alturas, Pettit, Stanley, and Yellowbelly lakes are presented in Table 1. These lakes drain to the upper Salmon River which flows into the Snake River and ultimately the Columbia River. Redfish Lake is located approximately 1,450 river km from the mouth of the Columbia River at the Pacific Ocean.

Fish species native to study area lakes and outlets include sockeye salmon/kokanee, spring/summer chinook salmon *O. tshawytscha*, rainbow trout/steelhead *O. mykiss*, westslope cutthroat trout *O. clarki lewisi*, bull trout *Salvelinus confluentus*, sucker *Catostomus sp.*, northern squawfish *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, redside shiner *Richardsonius balteatus*, dace *Rhinichthys sp.*, and sculpin *Cottus sp*. Non-native species include lake trout *S. namaycush* and brook trout *S. fontinalis*.

METHODS

Total Population, Density and Biomass Estimation

To estimate *O. nerka* population, density, and biomass, we conducted midwater trawling at night during the dark (new) phase of the moon. Redfish Lake was sampled in June, September, and October 1995. Alturas, Pettit, and Stanley lakes were sampled in September 1995. We did not sample Yellowbelly Lake as it was not accessible to our trawl boat.

Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). In 1995, we sampled a minimum of five trawl transects per lake per night.

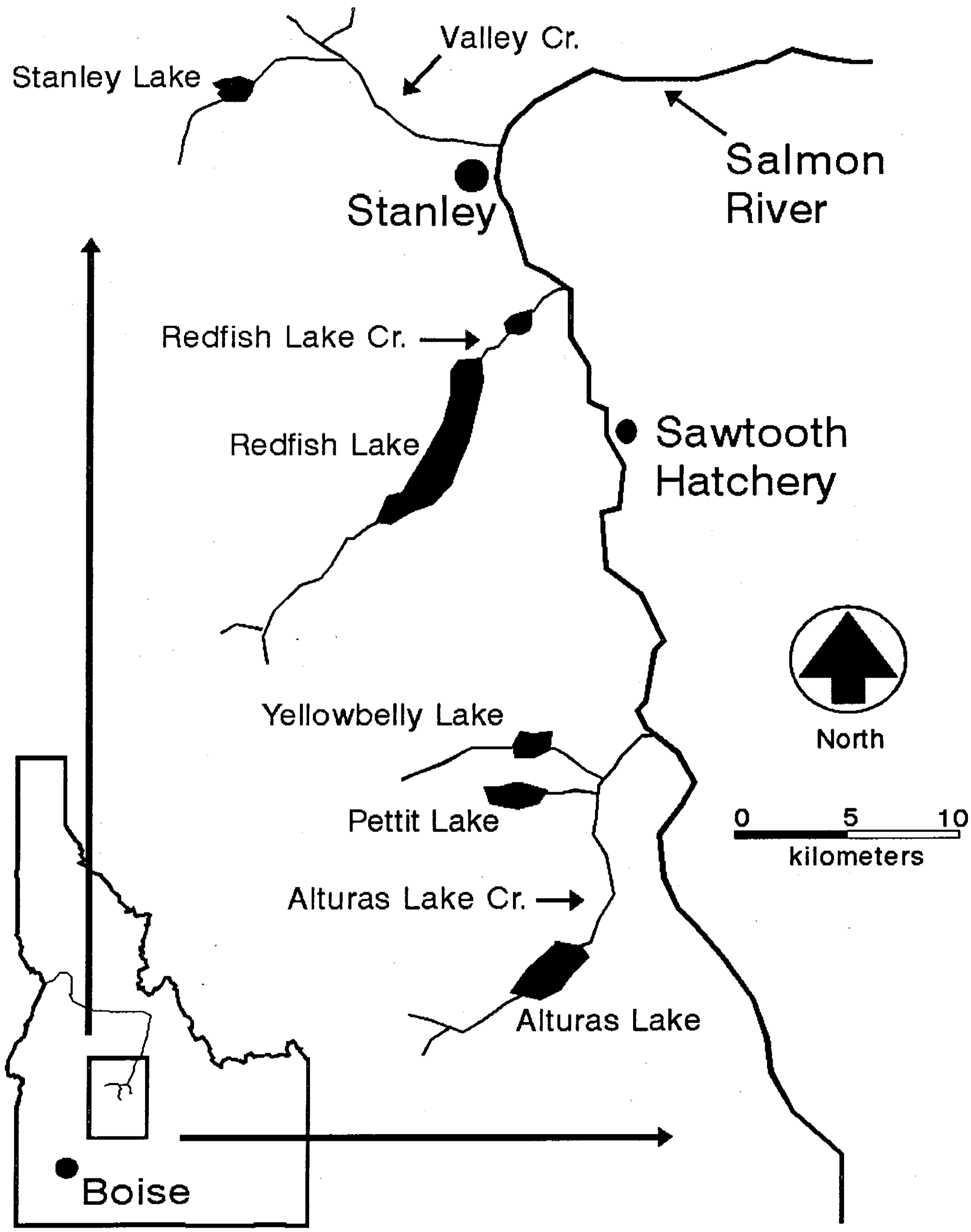


Figure 1. Stanley Basin study area map.

Table 1. Physical and morphometric characteristics of five Stanley Basin lakes.

Lake	Area (ha)	Elevation (m)	Volume (m^3x10^6)	Mean depth (m)	Maximum depth (m)	Drainage area (km^2)
Redfish	615	1,996	269.9	44	91	108.1
Alturas	338	2,138	108.2	32	53	75.7
Pettit	160	2,132	45.0	28	52	27.4
Stanley	81	1,985	10.4	13	26	39.4
Yellowbelly	73	2,157	10.3	14	26	30.4

We estimated total *O. nerka* population, density, and biomass using the TRAWL.WK1 spreadsheet for Lotus 123 developed by Rieman (1992). Population, density, and biomass estimates generated by this program are extrapolations of actual trawl catch data to the total area of the lake mid-depth in the observed sockeye salmon stratum. Whenever possible, we estimated population and density by individual age-class (assuming representation in the trawl).

We recorded fork length (to the nearest mm) and weight (to the nearest 0.1 g) for all trawl-captured *O. nerka*. Sagittal otoliths were removed from all fish, cleaned, and stored dry in microcentrifuge tubes. We surface-aged otoliths under transmitted and/or reflected light with the aid of a variable power dissecting microscope. Tissue samples were collected and preserved for genetic analysis by NMFS and University of Idaho technicians. Stomachs were removed and preserved for diet analysis by SBT biologists.

Outmigrant Monitoring

To estimate *O. nerka* outmigrant run size from Redfish, Alturas and Pettit lakes, IDFG personnel operated smolt traps on Redfish Lake Creek and on the upper Salmon River at the IDFG Sawtooth Fish Hatchery (FH).

The outmigrant trap on Redfish Lake Creek is located approximately 1.4 km downstream of the lake outlet. In 1995, the trap was placed in operation on April 19 and remained in place until June 15. Five of nine trap bays were operated with incline bar trap boxes. Bar spacing allowed debris and large fish to pass downstream while small fish were captured in the low velocity trap boxes. Remote PIT tag monitoring systems were installed on two of the five operating trap boxes to reduce fish handling without the loss of PIT tag interrogation data. The trap was checked twice daily by IDFG personnel.

The outmigrant trap on the Salmon River at the Sawtooth FH is located 2.0 km upstream of the confluence of Redfish Lake Creek and the Salmon River. The floating scoop trap, equipped with a 1.0 m wide inclined traveling screen, is installed directly below the permanent weir at the Sawtooth FH as part of IDFG natural production monitoring studies (Kiefer and Forster 1991). A picket weir, 3.1 m wide at the mouth, funnels fish through the trap. In 1995, the trap was operated continuously between March 10 and June 6 and was checked twice daily by IDFG personnel.

Juvenile trapping facilities were staffed between 08:00 and 10:00 hours to process outmigrants captured the previous night. Wild outmigrant sockeye salmon captured at Redfish Lake Creek and Sawtooth FH trap sites were anesthetized in buffered MS222 (Methane Tricaine Sulfonate), measured for fork length (to the nearest mm), weighed (to the nearest 0.1 g, Redfish Lake Creek only), and injected with PIT tags. Hatchery outmigrants (identified by the absence of their adipose fins) captured at the Redfish Lake Creek trap site were anesthetized in this same manner and scanned for PIT tags. PIT-tagged hatchery outmigrants were measured for fork length and weighed as for wild outmigrants. Non-PIT-tagged hatchery outmigrants were enumerated but were not PIT-tagged. All captured sockeye salmon were held in flow-through, low velocity live boxes at their respective trap sites and released approximately one-half hour after sunset.

We determined the trapping efficiency of the Redfish Lake Creek facility by releasing PIT-tagged wild outmigrants upstream for subsequent recapture. Due to the low number of outmigrant *O. nerka* captured at the Sawtooth FH weir, wild spring/summer chinook salmon recapture efficiencies were applied to juvenile outmigrant *O. nerka* (Kiefer and Lockhart 1996).

We estimated total emigration or outmigration run size by summing the products of trap efficiency and daily trap catch for five intervals within the total period of outmigration (Redfish Lake Creek only). Intervals were defined as periods of outmigration with similar stream discharge and recapture efficiency. We determined the variance of each interval using the following formula from Fleiss (1981):

$$V = \frac{pq}{N}$$

where V is the variance, p is the proportion in question, $q = 1\text{-}p$, and N is the sample size. Confidence limits (95%) for full season outmigration estimates were calculated using the following equations from Fleiss (1981):

$$Lower\ bound = P - c_{\alpha/2}\sqrt{\frac{pq}{N}} - \frac{1}{2N}$$

$$Upper\ bound = P + c_{\alpha/2}\sqrt{\frac{pq}{N}} + \frac{1}{2N}$$

where P is the total season outmigration estimate, $c_{\alpha/2}$ equals 0.025, and pq/N is the combined variance for all interval periods.

Captive Broodstock Program Juvenile Sockeye Salmon Supplementation

Although IDFG's captive broodstock program annual report appears under separate cover, a brief discussion of the supplementation that occurred in 1994 and 1995 to Stanley Basin waters is provided. This discussion is necessary for the reader to understand the basic research design and evaluation results related to juvenile sockeye salmon outmigration success presented in this report.

The first releases of hatchery-produced juvenile sockeye salmon to Redfish Lake occurred in 1994. Two release strategies were used with four broodstock lineages represented (Table 2). Prior to planting, all supplementation progeny were adipose fin-clipped and representative numbers injected with PIT tags. Mean fork lengths (to the nearest mm) and mean weights (to the nearest 0.1 g) were recorded during PIT tagging. In most cases, fish releases were made some time after the completion of PIT tagging, necessitating the collection of length and weight data more representative of conditions at the time of release. Representative mean release weights were estimated during hatchery inventory procedures conducted just prior to the transportation of fish for planting. Mean fork lengths at release were generally estimated using a weight-length relationship developed for captive broodstock sockeye salmon reared at IDFG's Eagle FH (Appendix A). Fish condition (presence - absence of cultural and congenital anomalies) was assessed during PIT tagging and documented in PIT tag data files.

All juvenile sockeye salmon produced for supplementation in 1994 (14,119) were planted in Redfish Lake as age 0+ pre-smolts. Supplementation fish were produced from brood year 1993 and brood year 1993.5 (off peak) spawning at Eagle FH. The majority of these fish were placed into lake net pens in mid-July with the remainder being released directly to the lake in late November (Table 2). Net pen fish were released to the lake in early August.

In 1995, 95,411 hatchery-produced sockeye salmon (brood year 1994) were planted to Stanley Basin waters over five release strategies. Compared to 1994 efforts, 1995 supplementation incorporated the release of additional broodstock lineage groups and release strategies in Redfish Lake, a yearling smolt release to Redfish Lake Creek, and a direct release to Pettit Lake (Table 3). All supplementation progeny released in 1995 were adipose fin-clipped and representative numbers PIT-tagged as described above. Mean time-of-release fork lengths and weights were estimated as described above.

We retrieved PIT tag interrogation data for mainstem Snake and Columbia river dams from the Columbia River Basin PIT Tag Information System (PTAGIS). Median travel times to Lower Granite Dam were calculated (where possible) for wild and hatchery-produced sockeye salmon. Because systems operations and fish handling potentially differ by date, arrival times to Lower Granite Dam were compared for wild and hatchery-produced progeny (by release strategy) using two sample Kolmogorov-Smirnov tests ($\alpha = .10$) (Sokal and Rohlf 1981).

Outmigrant Evaluations

As stated above (Objective 2), one objective of our research is to assess the contribution wild and hatchery-produced sockeye salmon make toward recovery. This information will be

Table 2. Hatchery-produced juvenile sockeye salmon planted into Redfish Lake in 1994.

Release Strategy	Broodstock Lineage[a]	Release Date	Number Released	Number PIT-tagged[b]	Mean Release Weight (g)	Mean Release Length (mm)
Redfish Lake Net Pens	OM91xAN93[c]	8/3/94	9,337	854	7.9	92
	AN93xAN93[c]	8/3/94	1,610	837	8.7	95
	BY91xBY91[c]	8/3/94	152	152	7.9	92
	OM91xOM91[c]	8/3/94	31	31	4.4	75
Direct to Redfish Lake	BY91xBY91[d]	11/23/94	2,989	854	8.1	89
TOTALS			14,119	2,728		

[a] OM91xAN93 refers to progeny of female Redfish Lake outmigrant smolts from 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.

AN93xAN93 refers to progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993.

BY91xBY91 refers to second generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.

OM91xOM91 refers to progeny of Redfish Lake outmigrant smolts collected in 1991.

[b] The number of PIT-tagged fish is included in the "number released" column.

[c] Sub-yearling releases from brood year 1993.

[d] Sub-yearling released from brood year 1993.5

Table 3. Hatchery-produced juvenile sockeye salmon planted into Stanley Basin waters in 1995.

Release Strategy	Broodstock Lineage[a]	Release Date	Number Released	Number PIT-Tagged[b]	Mean Release Weight (g)	Mean Release Length (mm)
Direct to Redfish Lake Creek	BY91xBY91[c]	4/21/95	3,277	854	14.0	108
	OM91xAN93[c]	4/21/95	346	346	202.0	288
	AN93xAN93[c]	4/21/95	171	171	153.0	251
Direct to Redfish Lake	OM91xBY91[d]	6/29/95	15,585	882	5.2	79
	BY91xBY91[d]	6/29/95	11,594	849	6.4	85
Direct to Pettit Lake	BY91xBY91[d]	7/27/95	8,572	861	7.4	90
Redfish Lake Net Pens	OM91xBY91[d]	10/10/95	18,207	855	11.7	107
	BY91xBY91[d]	10/10/95	9,956	866	11.0	104
Direct to Redfish Lake	OM91xBY91[d]	10/5/95	16,039	829	9.9	100
	BY91xBY91[d]	10/5/95	10,833	860	10.3	102
	AN94xBY/OM[d]	10/10/95	831	831	28.0	142
TOTALS			95,411	8,204		

[a] BY91xBY91 refers to second generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.
OM91xAN93 refers to progeny of female Redfish Lake outmigrant smolts from 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.
AN93xAN93 refers to progeny of the two females and six male sockeye salmon that returned to Redfish Lake Creek in 1993.
OM91xBY91 refers to progeny of female Redfish Lake outmigrant smolts from 1991 and first generation male progeny of the four sockeye salmon that returned to Redfish Lake Creek in 1991.
AN94xBY/OM refers to progeny of the one female sockeye salmon that returned to Redfish Lake Creek in 1994 and BY91 and OM91 males.
[b] The number of PIT-tagged fish is included in the "number released" column.
[c] Yearling releases from brood year 1993.5.
[d] Sub-yearling releases from brood year 1994.

used to develop future captive broodstock program spawning, rearing, and release designs to maximize the program's ability to efficiently use limited numbers of progeny.

We evaluated outmigration success by broodstock program release strategy at the Redfish Lake Creek trap and at lower Snake and Columbia river dams with fish bypass and PIT tag detection facilities (Lower Granite, Little Goose, Lower Monumental, and McNary dams). At the Redfish Lake Creek trap, PIT tag interrogation rates were used to compare outmigration success for the two broodstock program release strategy groups planted in Redfish Lake in 1994 and outmigrating in 1995 (Table 2). At mainstem dams, we used cumulative, unique PIT tag interrogation rates as a measure of relative outmigration success for sockeye salmon from the different broodstock program release strategies interrogated between April 19 and October 31, 1995. We defined cumulative, unique detections as the sum of first observation interrogations for individual fish at the first project where they were detected. Successive detections of individual fish were excluded (e.g., an individual fish detected at Lower Granite and Little Goose dams would be represented by only the Lower Granite detection information). Multiple, chi-square goodness of fit tests (paired by release strategy) were used to compare PIT tag interrogation data for both the Redfish Lake trap and mainstem dam locations (Zar 1974). Because broodstock lineages were not equally represented across all release strategies, no comparisons of outmigrant detection success by lineage among strategies were made. Individual broodstock lineages were pooled by release strategy to facilitate comparisons and to satisfy test requirements related to expected frequency cell size.

We used a priori power analysis for chi-square tests to determine PIT tag sample size (Cohen 1989). By establishing hypothetical over-winter survival rates and outmigration estimates and by applying a minimum estimate of cumulative, unique interrogation at mainstem Columbia and Snake river dams, we were able to develop an estimate of the number of PIT tag detections we should see for any one release lineage or release strategy. We were then able to establish a series of hypothetical detection proportions between test groups and compute different effect sizes to determine the total number of unique dam detections required to yield 0.80 power at the 0.10 significance level. Assuming the above assumptions would be met, we determined 850 fish from each broodstock lineage within each release strategy would need to be PIT-tagged to reach this level of power and increase our chances of correctly detecting an effect. Release groups with less than 850 individual fish were all PIT-tagged.

Redfish Lake Creek Trap

We established the following null hypothesis to evaluate outmigration success for hatchery-produced sockeye salmon interrogated at the Redfish Lake Creek trap in 1995:

> HoA: There is no significant difference ($P > 0.10$) in PIT tag detection rates observed at Redfish Lake Creek trap for hatchery-produced progeny planted in Redfish Lake in 1994 using two release strategies (expected detections will reflect actual tag proportions for the two release strategies).

This test compares interrogation rates for fish released from net pens on August 3, 1994 and fish released directly into Redfish lake on November 23, 1994. Number of fish released, number of fish PIT-tagged, and mean fork lengths and weights at release are presented in Table 2. All fish were planted as age 0+ pre-smolts in 1994 and were interrogated between April

19 and June 15, 1995 after spending one winter in Redfish Lake. No other comparisons were made for Redfish Lake Creek trap interrogation data in 1995.

Mainstem Snake and Columbia River Dams

We established the following null hypothesis to compare relative outmigration success of wild and hatchery-produced sockeye salmon interrogated between Lower Granite and McNary dams from April 19 through October 31, 1995:

> HoB: There is no significant difference ($P > 0.10$) in cumulative, unique PIT tag detection rates among wild and hatchery-produced sockeye salmon interrogated between Lower Granite and McNary dams from April 19 through October 31, 1995 (our assumption was detections would reflect actual tag proportions for release strategies).

Null hypothesis HoB represents 10 paired tests among 1995 wild outmigrants and hatchery-produced progeny from 1994 and 1995 release strategies. Test outcomes are presented individually and represent the following paired comparisons (refer to Tables 2 and 3 for a more detailed review of 1994 and 1995 release strategies):

1) August 3, 1994 Redfish Lake net pen and November 23, 1994 direct to Redfish Lake release strategies.

2) August 3, 1994 Redfish Lake net pen and April 21, 1995 direct to Redfish Lake Creek release strategies.

3) August 3, 1994 Redfish Lake net pen and June 29, 1995 direct to Redfish Lake release strategies.

4) November 23, 1994 direct to Redfish Lake and June 29, 1995 direct to Redfish Lake release strategies.

5) November 23, 1994 direct to Redfish Lake and April 21, 1995 direct to Redfish Lake release strategies.

6) April 21, 1995 direct to Redfish Lake Creek and June 29, 1995 direct to Redfish Lake release strategies.

7) Wild 1995 Redfish Lake outmigrants and August 3, 1994 Redfish Lake net pen release strategy.

8) Wild 1995 Redfish Lake outmigrants and November 23, 1994 direct to Redfish Lake release strategy.

9) Wild 1995 Redfish Lake outmigrants and April 21, 1995 direct to Redfish Lake Creek release strategy.

10) Wild 1995 Redfish Lake outmigrants and June 29, 1995 direct to Redfish Lake release strategy.

The above comparisons examine overall outmigration success of hatchery-produced progeny by release strategy and initial location of release (e.g., Redfish Lake release group evaluations were based on the number of PIT-tagged fish introduced to the lake in 1994 and not on the number of PIT-tagged fish interrogated at the Redfish Lake Creek trap in 1995). This approach best evaluates the release strategy as opposed to just the number of fish that successfully outmigrated from the lake. For comparisons 7, 8, and 10, it would have been of interest, however, to compare wild and lake release strategy group outmigration success at the dams using only the number of Redfish Lake Creek trap interrogations for the broodstock program fish that outmigrated from Redfish Lake. Results from such comparisons would have provided an additional index of outmigration success from an intermediate interrogation location - the Redfish Lake Creek trap. We did not attempt to make these comparisons, however, as doing so would have required our reliance on estimates of the total number of PIT-tagged fish from the two lake release strategies passing the Redfish Lake Creek trap. While these estimates were made and are reported later in the report, we did not feel they were appropriate to include in the evaluation. Hypothesis tests were designed to reflect actual cumulative, unique dam interrogations.

Volitional Spawning Investigations

Natural spawning characteristics of adult broodstock sockeye salmon released to Stanley Basin waters were evaluated in 1993 and 1994 (Kline 1994; Kline and Younk 1995). In 1995, no adults were released to spawn volitionally. Telemetry efforts in 1995 concentrated on determining the status of adults released to Redfish Lake in 1994 that were active at the termination of 1994 tracking efforts. In 1995, we conducted five tracking surveys between June 21 and September 21.

Three adult broodstock releases were made to Redfish Lake in 1994. The first release (30 fish) occurred August 9-10 and consisted of 11 brood year 1991 adult progeny of the four anadromous adult sockeye salmon that returned to Redfish Lake in 1991, 2 outmigrant 1992 adults, and 17 outmigrant 1991 adults (Appendix B). All brood year 1991 and outmigrant 1992 fish were fitted with ultrasonic transmitters. Eight of the outmigrant 1991 fish were fitted with ultrasonic transmitters. The second release (16 fish) occurred September 10 and consisted of 9 brood year 1991 adult progeny and 7 outmigrant 1991 adults (Appendix B). All fish in the second release group received ultrasonic transmitters. The third release occurred October 18 and consisted of 19 brood year 1992 residual sockeye salmon (Appendix B). These fish are the progeny of the beach-spawning residual component of Redfish Lake trapped over Sockeye Beach in 1992 for captive broodstock purposes. All of the residual broodstock releases were age 2+ males that matured earlier than their female counterparts. The absence of appropriate spawning partners necessitated their early release. None of the residual outplants were fitted with transmitters; however, each fish did receive an external tag to facilitate identification during subsequent snorkel investigations conducted in October and November 1994 by the SBT.

Ultrasonic telemetry equipment was purchased through Sonotronics (Tucson, Arizona). Individual transmitter frequencies ranged from 70 to 76 KHz. Tag frequencies were coded with unique, self-identifying codes allowing several tags to be assigned the same tracking frequency. The tags were 65 mm long, 18 mm wide, and weighed 22 g (out of water).

We tracked fish by boat using a Sonotronics model USR-5W receiver with a model DH-2-10 directional hydrophone. We used the point of maximum transmitter signal strength to indicate location. Individual fish locations were mapped on USGS 7½ minute topographic maps using triangulation with known shoreline landmarks. We assumed the landmarks, from which we took bearings, were mapped correctly. A global positioning system (GPS) was also used to record individual fish positions and to relocate individual fish on successive survey dates.

Predator Investigations

In 1995, we surveyed potential spawning locations on the principal tributary streams of Redfish and Alturas lakes to establish suitable index areas for monitoring bull trout population response to no-harvest fishing regulations implemented by IDFG in January 1994. Adult bull trout spawner and redd surveys were conducted on September 8 in both drainages. Alturas Lake Creek (Figure 2) was walked from its confluence with Alturas Lake upstream to a location approximately 0.5 km upstream from its confluence with Alpine Creek (approximately 3.0 km). We surveyed about 1.5 km of Alpine Creek upstream of its confluence with Alturas Lake Creek. Fishhook Creek was surveyed from the Bench Lakes trail head upstream to the United States Forest Service Sawtooth Wilderness boundary (approximately 3.0 km) (Figure 2). Visual observations of bull trout and bull trout redds were recorded. Unattended redds were identified as bull trout redds by their typically large size.

Parental Lineage Investigations

We used otolith microchemistry to improve our knowledge of the parental lineage of wild and broodstock sockeye salmon. In 1995, sagittal otoliths were removed from 84 individual fish to increase our sample size of known lineage otoliths to better define equivocal results from past analyses.

Samples were collected from 21 first generation progeny of the eight anadromous adult sockeye salmon (six males, two females) that returned to Redfish Lake Creek in 1993, 43 first generation progeny of the single female anadromous adult that returned to Redfish Lake Creek in 1994, and 20 adult male kokanee spawners collected in Fishhook Creek in 1995. In all cases, otolith samples represented known lineage to anadromous sockeye salmon or Fishhook Creek kokanee parents (Table 4). We hypothesized Sr/Ca ratios from otolith nuclei of fish with known lineage to female anadromous and fresh water parents would reflect the appropriate life history and conform to Sr/Ca criteria established by Rieman et al. (1993) and supported by Kline (1994) and Kline and Younk (1995).

The preparation of otoliths for microchemistry analysis followed procedures developed by Kalish (1990) and Rieman et al. (1993). Sample preparations were analyzed at Oregon State University (College of Oceanography, Corvallis, OR 97331-5503) and followed procedures outlined by Toole and Nielsen (1992). Microprobe transects were run in otolith nuclei adjacent to the primordia for all samples (10 microprobe sites analyzed per transect).

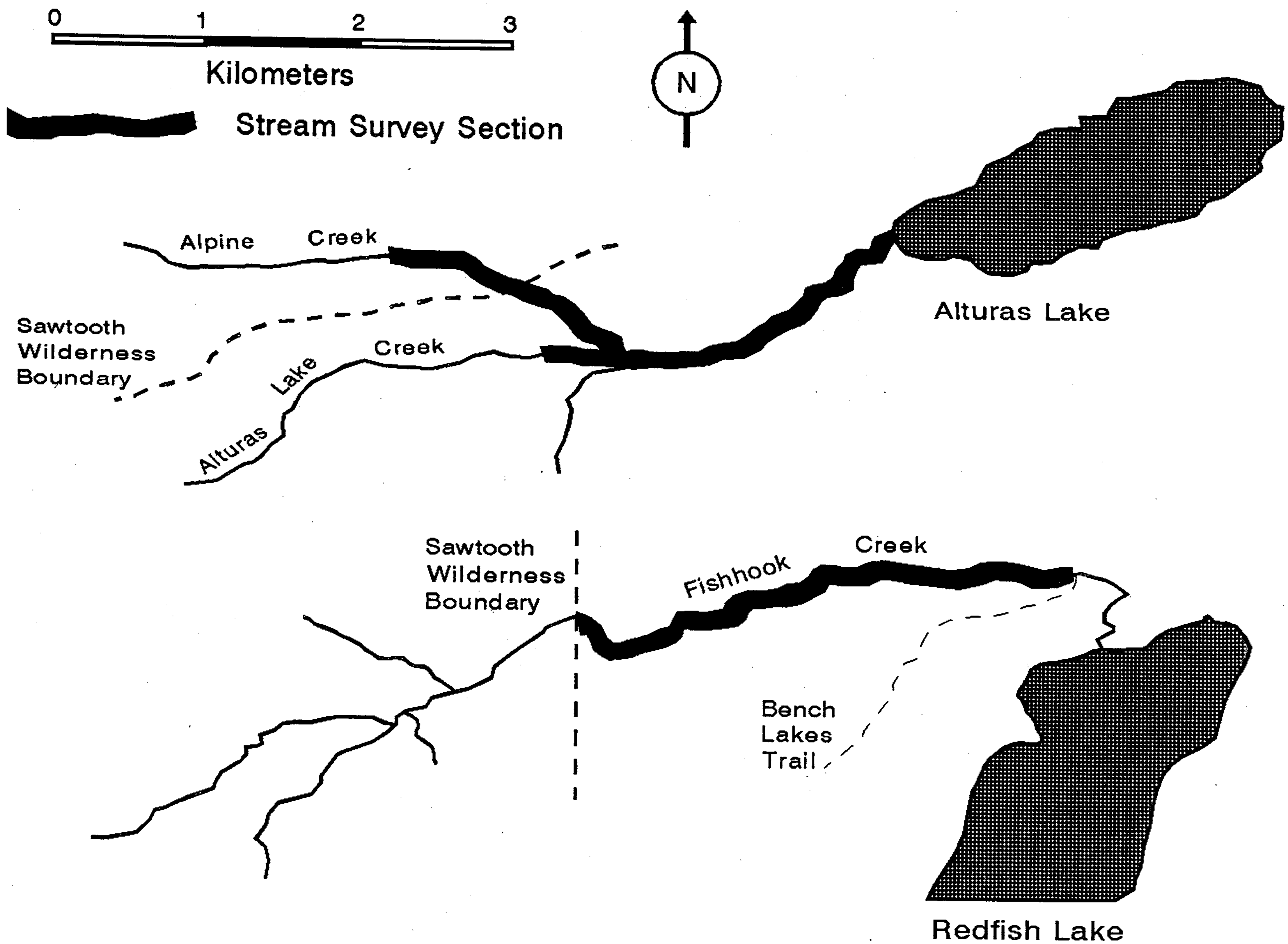


Figure 2. Location of bull trout spawner and redd survey sections on tributary streams of Alturas and Redfish lakes.

Table 4. Origin and number of *O. nerka* sagittal otoliths selected for 1995 microchemistry analysis.

Identification	Origin	Number analyzed
Fishhook Creek kokanee spawners[a]	known (freshwater)	20
Brood year 1993 progeny[b]	known (anadromous)	21
Brood year 1994 progeny[c]	known (anadromous)	43

[a] Adult male kokanee spawners removed from Fishhook Creek (kokanee spawning tributary to Redfish Lake) in 1995.

[b] Progeny of the two anadromous adult female sockeye salmon that returned to Redfish Lake Creek in 1993.

[c] Progeny of the one anadromous adult female sockeye salmon that returned to Redfish Lake Creek in 1994.

Redfish Lake Kokanee Fishery Investigation

We conducted a stratified creel survey on Redfish Lake from July 15 through July 31 (the full length of the 1995 season open to kokanee harvest). The census consisted of one 17-day interval. We stratified the survey by weekday and weekend day types and morning (06:00 to 11:00), midday (11:00 to 16:00), and evening (16:00 to 21:00) day periods. We selected two weekdays and one weekend day for angler counts during each week of the census. On each survey date, three counts were made (one in each day period). We selected angler count dates and starting times non-randomly based on the availability of interview personnel.

Angler counts were made by boat. Creel personnel counted the number of boats fishing and the number of bank anglers fishing. Boat counts were adjusted based on the number of anglers per boat determined from interviews. Angler interviews were conducted on count dates following the completion of each count. We recorded number of anglers, hours fished, and angler type. We asked anglers how many fish they had harvested or released by species. Spot checks of creeled kokanee were made to check fish length and to look for the presence of an adipose fin clip. Information was also sought regarding the extent of injuries and/or mortalities associated with the use of barbed hooks on released fish.

We distributed angler diaries to three Stanley businesses. Diaries were used by business clients as well as business owners. Angler information requested on diary forms matched that collected during the interview process and was incorporated in the survey.

Creel data were analyzed using the Creel Census System computer program developed by McArthur (1992).

RESULTS

Total Population, Density, and Biomass Estimation

Redfish Lake

We estimated *O. nerka* population, density, and biomass from September and October trawl data. During the October trawl, additional information on the distribution of hatchery-produced juvenile sockeye salmon was sought. June trawl data was used to assist SBT biologists with the calibration of hydroacoustic gear. The September trawl occurred approximately 2 months after the June 29, 1995 direct release to Redfish Lake of 27,179 hatchery-reared sockeye salmon and approximately 10 months after the last release of hatchery-reared sockeye salmon in 1994 (Tables 2 and 3). The October trawl occurred approximately two weeks after the direct release of 55,866 additional hatchery-produced juvenile sockeye salmon from net pen and direct lake release options on October 5 and 10. We captured 7 *O. nerka* during the June trawl, 77 *O. nerka* during the September trawl and 22 *O. nerka* during the October trawl. One and six fish from the September and October trawls, respectively, were of hatchery origin. No hatchery-reared sockeye salmon were captured during the June trawl.

Echo chart patterns from the September 26 trawl of Redfish Lake indicated the majority of *O. nerka* targets were tightly stratified in the limnetic zone between 9 m and 19 m of depth. Our September trawl catch consisted of 76 wild and 1 adipose fin-clipped hatchery-produced *O. nerka*. Two redside shiners were also captured during the September trawl. We estimated the total wild Redfish Lake *O. nerka* population to be 61,646 fish (95% CI, ±27,639). Total *O. nerka* density and biomass were estimated to be 150 fish/hectare (95% CI, ±67) and 6.5 kg/hectare, respectively (Table 5). Thirty-four percent of the total *O. nerka* catch consisted of age 0+ fish, while 13%, 52%, and 1% were age 1+, 2+, and 3+ fish, respectively (Tables 6 and 7). Age 0+, 1+, 2+, and 3+ fish averaged 63 mm, 99 mm, 189 mm, and 204 mm in fork length, respectively (Figure 3). Mean weights for these age classes were 2.4 g, 9.4 g, 77.3 g, and 100.6 g, respectively (Appendix C). The one adipose fin-clipped hatchery sockeye salmon captured during the trawling on September 26 measured 111 mm in fork length and weighed 15.0 g. As this individual was not PIT-tagged, identification of broodstock lineage and release strategy was not possible. We did not attempt to estimate hatchery sockeye salmon population variables from September 1995 trawl data.

Echo chart patterns from the October 24, 1995 trawl indicated *O. nerka* targets were loosely stratified in the limnetic zone between 7 m and 27 m of depth. We observed fewer targets during the October survey than one month earlier during the September survey. Twenty-two *O. nerka* were captured consisting of 16 wild and 6 hatchery individuals. No species other than *O. nerka* were captured. Wild fish population numbers were estimated at 25,349 (±12,674) fish. Density and biomass for the October trawl were estimated at 62 fish/hectare (±31) and 1.3 kg/hectare, respectively. Age 0+, 1+, and 2+ fish were represented in the trawl catch. Mean fork lengths and weights by age-class were 65 mm and 2.4 g, 96 mm and 8.9 g, and 179 mm and 67.0 g, respectively (Figure 4; Appendix C).

Table 5. Estimated *O. nerka* total population, density (fish/hectare), and biomass (kilograms/hectare) in four Stanley Basin lakes, 1990 - 1995. Data represent fall sample dates as indicated.

Lake	Date	Total Population (±95% C.I.)	Density (±95% C.I.)	Biomass
Redfish	9/26/95	61,646 (±27,639)	149.6 (±67.1)	6.51
Redfish	9/06/94	51,529 (±33,179)	125.1 (±80.1)	2.11
Redfish	9/17/93	49,628--[a]	120.4--[a]	2.34
Redfish	9/29/92	39,481 (±10,767)	95.9 (±26.1)	1.46
Redfish	8/20/90	24,431 (±11,000)	63.9 (±26.6)	1.30
Alturas	9/25/95	23,061 (±9,182)	108.7 (±43.3)	2.64
Alturas	9/07/94	5,785 (±6,919)	27.1 (±33.6)	0.68
Alturas	9/17/93	49,037 (±13,175)	230.2 (±61.9)	4.12
Alturas	9/25/92	47,237 (±61,868)	222.8 (±291.8)	3.86
Alturas	9/08/91	125,045 (±30,708)	594.0 (±144.8)	6.33
Alturas	8/19/90	126,644 (±31,611)	597.0 (±154.0)	5.20
Pettit	9/24/95	59,002 (±15,735)	513.1 (±136.8)	20.75
Pettit	9/08/94	14,743 (±3,683)	128.2 (±32.0)	4.40
Pettit	9/18/93	10,511 (±3,696)	101.0 (±33.9)	1.09
Pettit	9/27/92	3,009 (±2.131)	26.2 (±18.5)	3.50
Stanley	9/27/95	1,021 (±702)	13.3 (±9.6)	0.24
Stanley	9/07/94	2,694 (±913)	36.9 (±12.5)	0.49
Stanley	9/16/93	1,325 (±792)	18.9 (±11.3)	0.57
Stanley	8/28/92	2,117 (±1,592)	29.0 (±21.8)	0.27

[a] Confidence limits not calculated - single transect estimate.

Table 6. Estimated *O. nerka* total population by age-class in four Stanley Basin lakes, 1990-1995. Values in parentheses are 95% confidence limits. Data represent fall sample dates from Table 5.

Lake	0+	I+	II+	III+	IV+
Redfish	20,836	8,000	32,008	802	0
1995	(±11,057)	(±5,342)	(±24,761)	(±1,604)	(±0)
Redfish	30,449	5,856	15,224	0	0
1994	(±25,780)	(±8,867)	(±18,884)	(±0)	(±0)
Redfish	26,120	7,836	15,672	0	0
1993	---[a]	---	---	---	---
Redfish	22,954	5,509	3,213	3,902	3,902
1992	(±4,899)	(±8,415)	(±4,002)	(±1,655)	(±1,665)
Redfish	10,048	8,808	3,338	2,237	0
1990	(±7,308)	(±5,288)	(±2,595)	(±2,261)	(±0)
Alturas	412	1,646	2,470	14,818	3,705
1995	(±823)	(±1,646)	(±2,551)	(±8,066)	(±3,059)
Alturas	0	0	5,785[b]		0
1994	(±0)	(±0)	(±6,919)		(±0)
Alturas	0	1,226	39,842	7,969	0
1993	(±0)	(±1,501)	(±12,412)	(±4,157)	(±0)
Alturas	0	1,377	11,912	32,667	1,281
1992	(±0)	(±2,368)	(±22,280)	(±57,612)	(±2,561)
Alturas	5,556	67,217	48,569	3,702	0
1991	(±1,657)	(±20,999)	(±22,146)	(±2,965)	(±0)
Alturas	39,065	12,126	55,439	15,075	4,948
1990	(±17,888)	(±6,325)	(±28,284)	(±6,324)	(±2,850)
Pettit	0	13,566	43,406	2,032	0
1995	(±0)	(±3,542)	(±15,151)	(±2,346)	(±0)
Pettit	4,095	6,826	3,276	546	0
1994	(±1,930)	(±2,730)	(±1,392)	(±668)	(±0)
Pettit	10,511	0	362	362	362
1993	(±3,696)	(±0)	(±725)	(±725)	(±725)
Pettit	0	0	0	0	3,009
1992	(±0)	(±0)	(±0)	(±0)	(±2,131)
Stanley	656	183	183	0	0
1995	(±614)	(±242)	(±242)	(±0)	(±0)
Stanley	2,087	606	0	0	0
1994	(±796)	(±448)	(±0)	(±0)	(±0)
Stanley	0	714	103	509	0
1993	(±0)	(±516)	(±206)	(±565)	(±0)
Stanley	0	1,902	0	215	0
1992	(±0)	(±1,533)	(±0)	(±429)	(±0)

[a] Confidence limits not calculated - single transect estimate.
[b] Alturas Lake population estimate not partitioned by age-class.

Table 7. Estimated *O. nerka* density (fish/hectare ±95% confidence limits) by age-class in four Stanley Basin lakes, 1990-1995. Data represent fall sample dates from Table 5.

Lake	0+	I+	II+	III+	IV+
Redfish 1995	50.6 (±26.8)	19.4 (±13.0)	77.7 (±60.1)	1.9 (±3.9)	0.0 (±0.0)
Redfish 1994	73.9 (±62.2)	14.2 (±21.5)	37.0 (±45.8)	0.0 (±0.0)	0.0 (±0.0)
Redfish 1993	63.4 ---[a]	19.0 ---	38.0 ---	0.0 ---	0.0 ---
Redfish 1992	55.7 (±11.8)	13.4 (±20.4)	7.8 (±9.7)	9.5 (±4.0)	9.5 (±4.0)
Redfish 1990	26.3 (±19.7)	23.1 (±14.6)	8.7 (±7.1)	5.9 (±7.2)	0.0 (±0.0)
Alturas 1995	1.9 (±3.9)	7.8 (±7.8)	11.6 (±12.0)	69.9 (±38.0)	17.5 (±14.4)
Alturas 1994	0.0 (±0.0)	0.0 (±0.0)	27.1[b] (±33.6)		0.0 (±0.0)
Alturas 1993	0.0 (±0.0)	5.7 (±7.0)	187.1 (±58.3)	37.4 (±19.5)	0.0 (±0.0)
Alturas 1992	0.0 (±0.0)	6.5 (±11.2)	56.2 (±105.1)	154.1 (±271.8)	6.0 (±12.1)
Alturas 1991	26.2 (±7.8)	317.1 (±99.0)	229.1 (±104.5)	17.5 (±13.9)	0.0 (±0.0)
Alturas 1990	184.3 (±82.4)	57.2 (±30.8)	261.5 (±122.0)	71.1 (±31.3)	23.3 (±13.4)
Pettit 1995	0.0 (±0.0)	118.0 (±30.8)	377.7 (±131.7)	17.7 (±20.4)	0.0 (±0.0)
Pettit 1994	35.6 (±16.8)	59.4 (±23.7)	28.5 (±12.1)	4.8 (±4.9)	0.0 (±0.0)
Pettit 1993	91.4 (±32.1)	0.0 (±0.0)	3.2 (±6.3)	3.2 (±6.3)	3.2 (±6.3)
Pettit 1992	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)	26.2 (±18.5)
Stanley 1995	9.0 (±8.4)	2.5 (±3.3)	2.5 (±3.3)	0.0 (±0.0)	0.0 (±0.0)
Stanley 1994	27.8 (±10.8)	7.9 (±6.1)	0.0 (±0.0)	0.0 (±0.0)	0.0 (±0.0)
Stanley 1993	0.0 (±0.0)	10.2 (±7.4)	1.5 (±3.0)	7.3 (±8.1)	0.0 (±0.0)
Stanley 1992	0.0 (±0.0)	26.1 (±21.0)	0.0 (±0.0)	2.9 (±5.9)	0.0 (±0.0)

[a] Confidence limits not calculated - single transect estimate.
[b] Alturas Lake density estimate not partitioned by age-class.

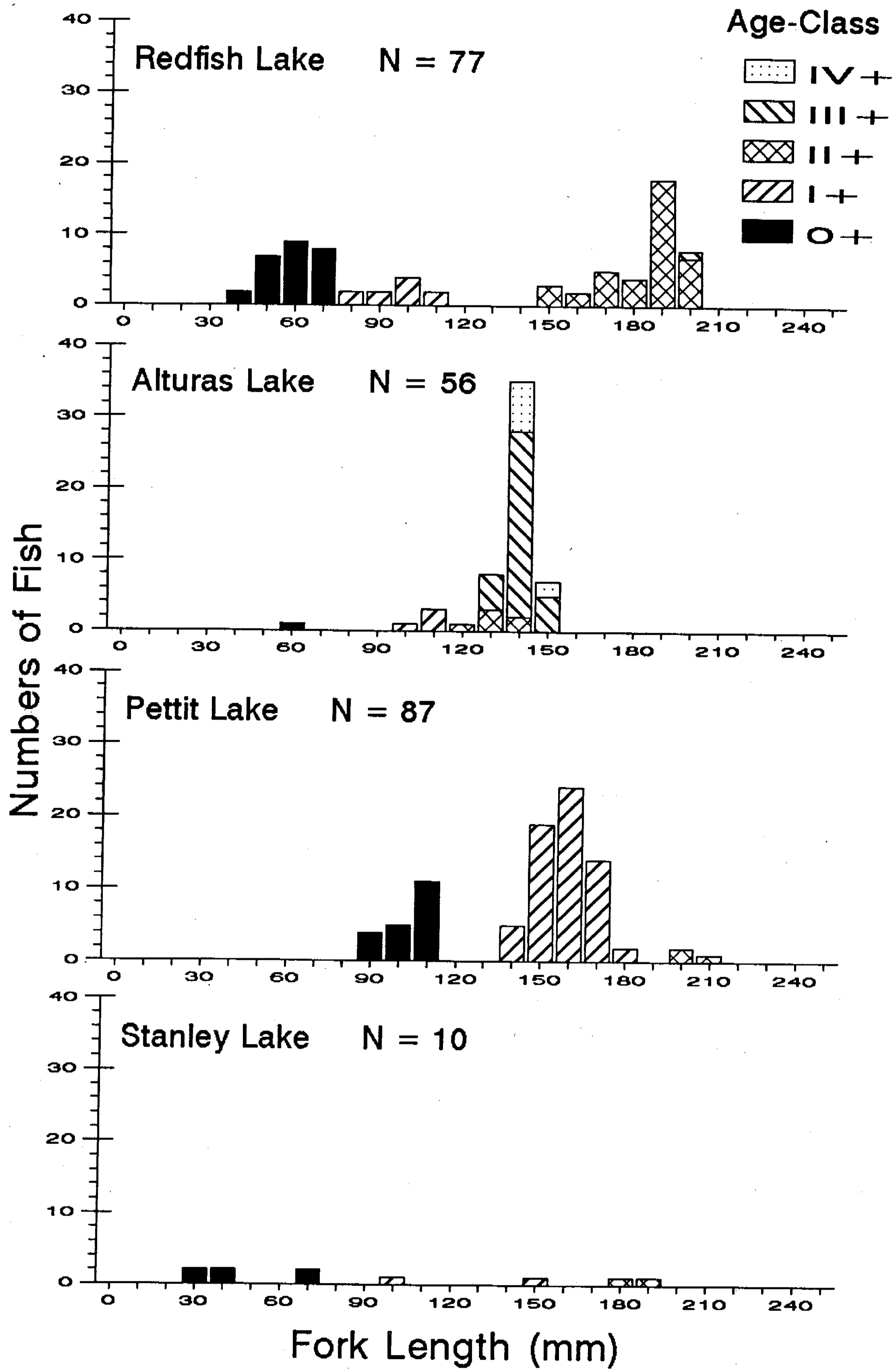


Figure 3. Length-frequency distributions of *O. nerka* from September 1995 midwater trawls of four Stanley Basin lakes.

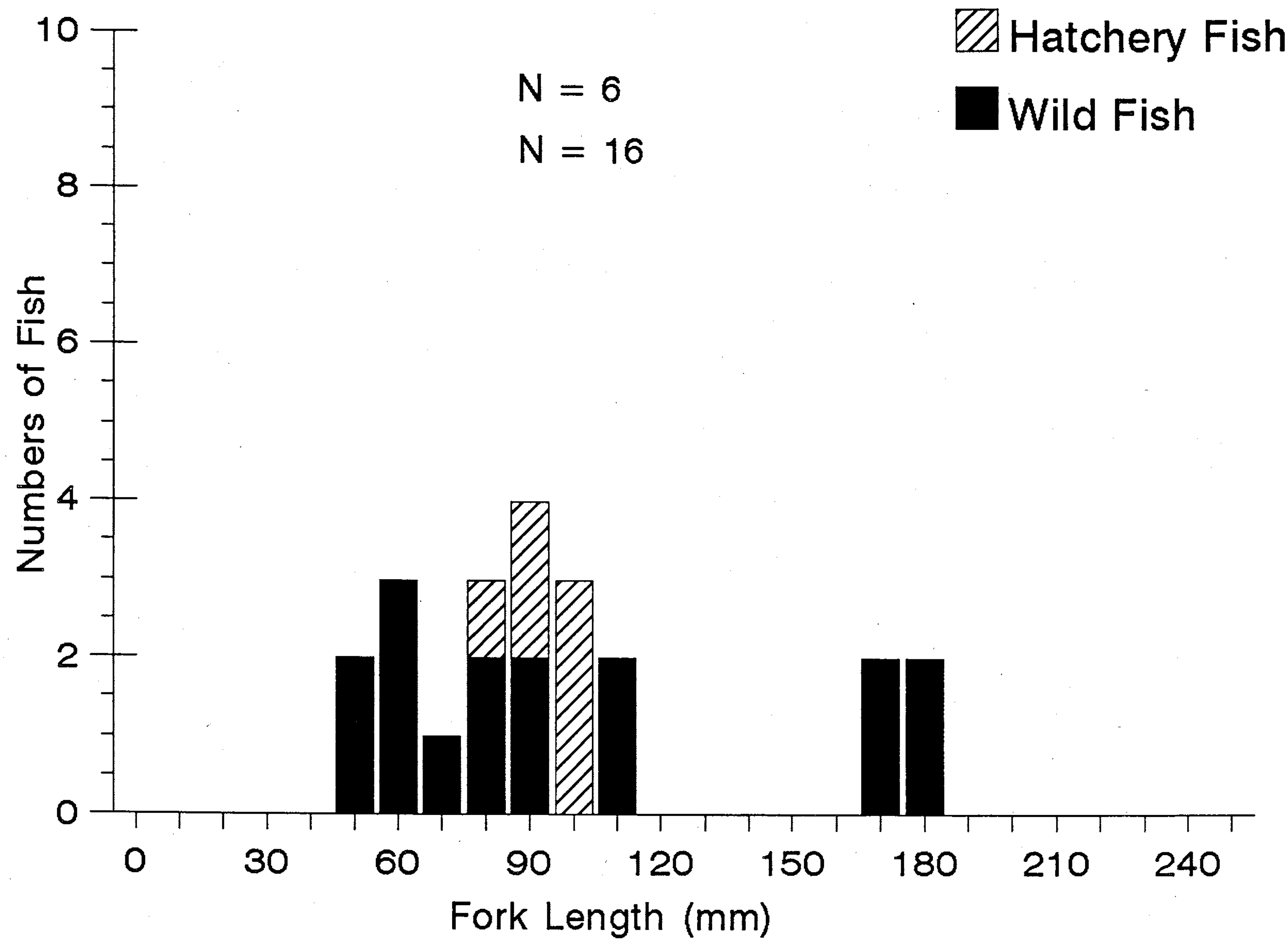


Figure 4. Length-frequency distribution of *O. nerka* from October 1995 midwater trawl of Redfish Lake.

The total population of hatchery sockeye salmon from captive broodstock program releases estimated in Redfish Lake from October trawl data was 9,506 (±0) fish. Hatchery trawl captures averaged 99 mm in fork length (range 87 mm to 109 mm) and 10.8 g in weight (range 6.8 g to 16.1 g) (Figure 4; Appendix C). No PIT tags were recovered from any of the six hatchery fish captured during the October survey.

Alturas Lake

In 1995, *O. nerka* comprised 100% of the September 25, Alturas Lake trawl catch. Fish were stratified between 11 m and 27 m of depth although targets were visible to 44 m. Deep targets (>27 m) did not exhibit a pattern of stratification and were not sampled by trawling. Fifty-six *O. nerka* were captured expanding to an estimated total population of 23,061 fish (±9,182). Total density for the September population was estimated at 109 fish/hectare (±43). We estimated the total *O. nerka* biomass to be 2.6 kg/hectare (Table 5). Age 0+, 1+, 2+, 3+, and 4+ fish were represented in the trawl catch with age 3+ fish comprising 64% of the sample (Tables 6 and 7). Mean fork lengths of Alturas Lake trawl captures were 68 mm, 110 mm, 135 mm, 144 mm, and 147 mm for age classes 0 through 4, respectively (Figure 3). Mean fish weights for these same age-classes were 2.7 g, 12.9 g, 21.9 g, 26.1 g, and 26.4 g (Appendix C).

Pettit Lake

During the September 27, 1995 survey, Pettit Lake fish targets were stratified between 7 m and 44 m in depth. Trawling occurred 62 d after the release of 8,572 hatchery-produced sub-yearling sockeye salmon to Pettit Lake (Table 3). Eighty-seven *O. nerka* and one redside shiner were captured during the survey. No hatchery-produced sockeye salmon were observed in the sample. The total kokanee population estimate for Pettit Lake was 59,002 fish (±15,735). We estimated total kokanee density and biomass at 513 fish/hectare (±137) and 20.8 kg/hectare, respectively (Table 5). Age-classes 1 through 3 were represented in the trawl with age 2+ fish comprising the majority (74%) of the sample (Tables 6 and 7). Mean fork lengths for age-classes 1 through 3 were 106 mm, 162 mm, and 209 mm, respectively (Figure 3). We recorded mean weights of 11.8 g, 46.5 g, and 103.5 g for these same groups (Appendix C).

Stanley Lake

The majority of limnetic targets observed during our September 27 survey of Stanley Lake were loosely stratified between the lake surface and 13 m in depth. Larger, unstratified, targets (that we did not attempt to sample) were noted below our identified fish layer and immediately above the lake bottom. Fifty-three percent of the catch consisted of *O. nerka* (10 fish); the remainder (47%) consisted of redside shiners (9 fish). We estimated the total September *O. nerka* population of Stanley Lake to be 1,021 (±702) fish. Total density and biomass were estimated at 13 fish/hectare (±10), and 0.24 kg/hectare, respectively (Table 5). Age 0+, 1+, and 2+ fish comprised the entire *O. nerka* catch (age 0+ fish accounted for

64% of the sample) (Tables 6 and 7). Mean fork lengths for age-classes 0, 1, and 2 were 52 mm, 126 mm, and 189 mm, respectively (Figure 3). Mean weights for these three age-classes were 1.8 g, 25.0 g, and 64.7 g (Appendix C).

Outmigrant Monitoring

Redfish Lake

We trapped a total of 109 wild and 219 hatchery-produced *O. nerka* outmigrants at the Redfish Lake trap site in 1995. Forty-nine spring/summer chinook salmon and two steelhead juveniles were also captured during 1995 trapping efforts. Trap captures occurred between April 19 and June 15 with peak sockeye salmon emigration taking place between May 15 and May 25 (Figure 5). Peak emigration coincided with the rising leg of the seasonal hydrograph at stream flows of approximately 2.0 m^3/s to 4.0 m^3/s (Figure 5). Outmigrants were captured primarily during night hours. In 1995, no mortalities associated with trapping or handling outmigrants occurred.

Wild Outmigrants - We estimated 357 wild *O. nerka* (95% CI 185 to 532) outmigrated from Redfish Lake in 1995. Recapture efficiencies used to estimate outmigration ranged from 23% (±23%) to 67% (±24%) for our five periods of trap efficiency (Table 8). The mean fork length and mean weight of wild outmigrants was 101 mm (range 82 mm to 147 mm) and 9.3 g (range 4.8 to 29.0 g), respectively (Table 9). As no trapping or handling mortalities were recorded in 1995, no determination of fish age was made (sagittal otoliths are preferred for this purpose; handling fish to remove scales for ageing was avoided as it frequently causes excessive scale loss in sockeye salmon undergoing smoltification). About 88% of the 1995 outmigration consisted of age 1+ smolts (fork length range 82 mm to 119 mm) and 12% age 2+ smolts (fork length range 120 mm to 149 mm) based on interpretation of 1995 length frequency data and comparison with age data from past outmigration years (Figure 6).

Travel times to juvenile fish bypass systems operating at Lower Granite, Little Goose, Lower Monumental, and McNary dams are presented in Table 10. The median travel time to Lower Granite Dam in 1995 was 10.7 d. Twenty-seven of the 109 PIT-tagged wild outmigrants were detected at one of the above facilities yielding a cumulative, unique interrogation rate of 24.8% (Table 11). This number represents in-river minimum survival through McNary Dam and only documents the number of fish successfully diverted through and detected by the interrogation systems at these facilities. It does not account for fish that avoid juvenile bypass systems by negotiating turbines or passing projects via spillways or locks. In 1995, all PIT-tagged fish detected between Lower Granite and McNary dams were diverted back to the river via system slide gates.

The arrival time of wild outmigrants to Lower Granite Dam coincided with the arrival times of outmigrants from two of four release strategies interrogated between April 19 and October 31, 1995. No significant difference among frequency distributions of arrival times to Lower Granite Dam was observed for wild, April 21, 1995 direct to Redfish Lake Creek (two of four lineages represented), and August 3, 1994 Redfish Lake net pen (two of three lineages

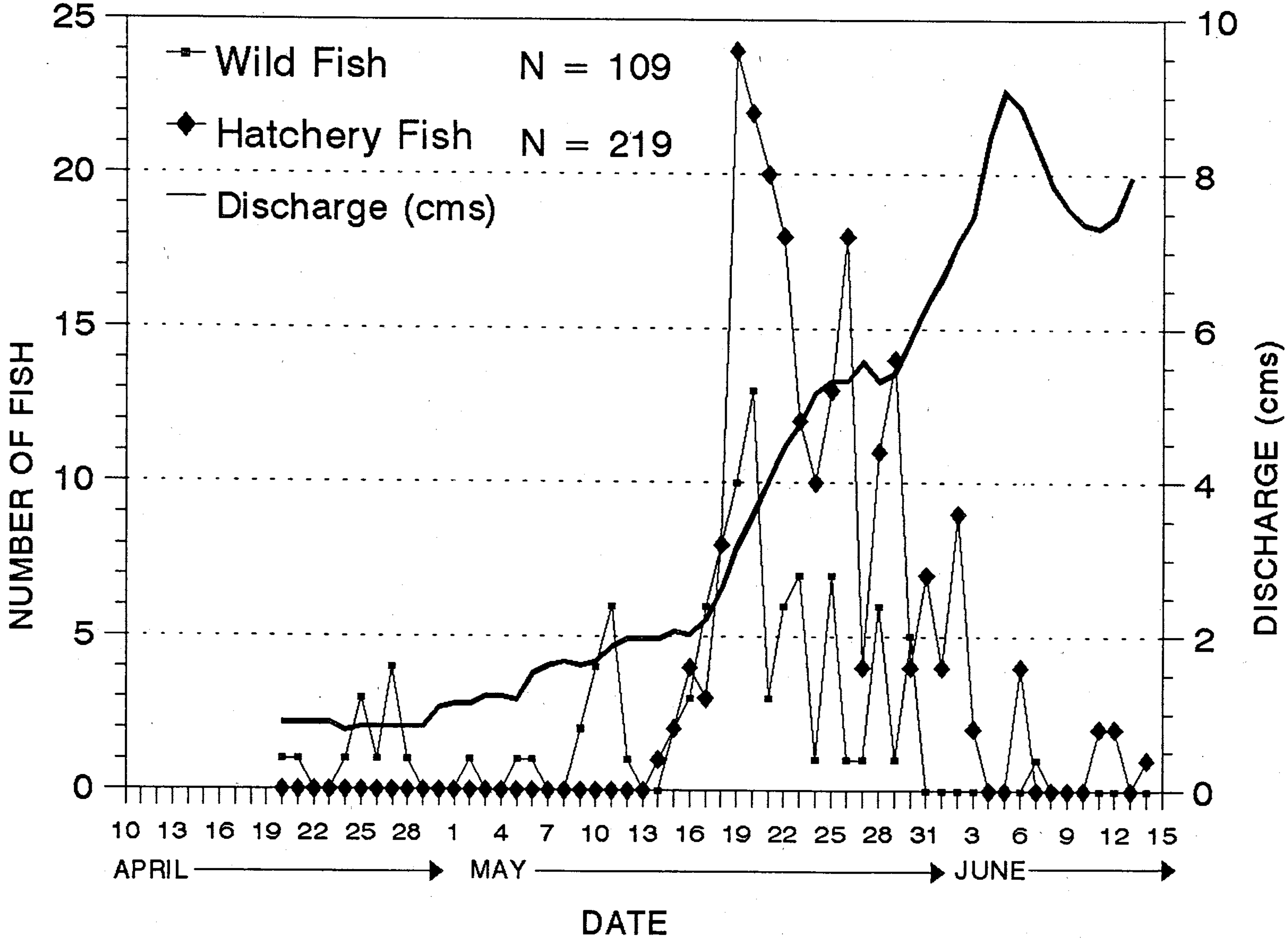


Figure 5. Numbers of outmigrant *O. nerka* captured at the Redfish Lake Creek trap in 1995. Data represent trap counts, not expanded estimates.

Table 8. Actual and estimated numbers of wild and hatchery-produced outmigrants captured at the Redfish Lake Creek trap between April 19 and June 15, 1995 for five trapping efficiency periods.

	Trapping Efficiency Periods				
	4/19-5/8	5/9-5/14	5/15-5/21	5/22-5/27	5/28-6/15
No. of Wild Fish Trapped	15	13	45	23	13
No. of Hatchery-Produced Fish Trapped[a]	0	1	83	75	60
No. of Wild Fish Recaptured	10	7	11	8	3
Trapping Efficiency Estimate[b]	0.67	0.54	0.24	0.35	0.23
Variance of Efficiency Estimate	0.015	0.019	0.004	0.010	0.014
95% CI Around Efficiency Estimate	0.24	0.27	0.13	0.19	0.23
Estimated Total Wild sockeye salmon Outmigration	23	24	184	66	56
Estimated Total Hatchery-Produced *O. nerka* Outmigration	0	2	346	214	261

[a] PIT-tagged and un PIT-tagged hatchery-produced outmigrants combined.

[b] Efficiency estimates based on the release and recapture of wild *O. nerka* outmigrants only.

Table 9. Fork lengths and weights of wild and hatchery-produced *O. nerka* outmigrants captured at the Redfish Lake Creek trap between April 19 and June 15, 1995.

Origin and Release Date	Broodstock Lineage[a]	Sample Size	Mean Fork Length and (Range) (mm)	Mean Weight and (Range) (g)
Wild 4/19-6/15/95			101 (82-147)	9.3 (4.8-29.0)
Redfish Lake Net Pens 8/3/94	OM91xAN93	13	112 (101-129)	12.6 (9.4-19.7)
	AN93xAN93	6	118 (108-129)	13.9 (10.7-16.1)
	Combined	19	114 (101-129)	13.0 (9.4-19.7)
Direct to Redfish Lake 11/23/94	BY91xBY91	1	105 ([b])	11.4 ([b])
Combined Broodstock Program-Produced Fish[c]		20	113 (101-129)	12.9 (9.4-19.7)

[a] OM91xAN93 refers to brood year 1993 progeny of female Redfish Lake outmigrant smolts collected in 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.

AN93xAN93 refers to brood year 1993 progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993.

BY91xBY91 refers to second generation brood year 1993.5 progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.

[b] Only one fish in the sample, no range.

[c] Between April 19 and June 15 1995, 28 PIT-tagged sockeye salmon were interrogated at the Redfish Lake Creek trap (see Appendix C). Eight of these interrogations were from the one remote PIT tag interrogation system operating in 1995 and were not handled.

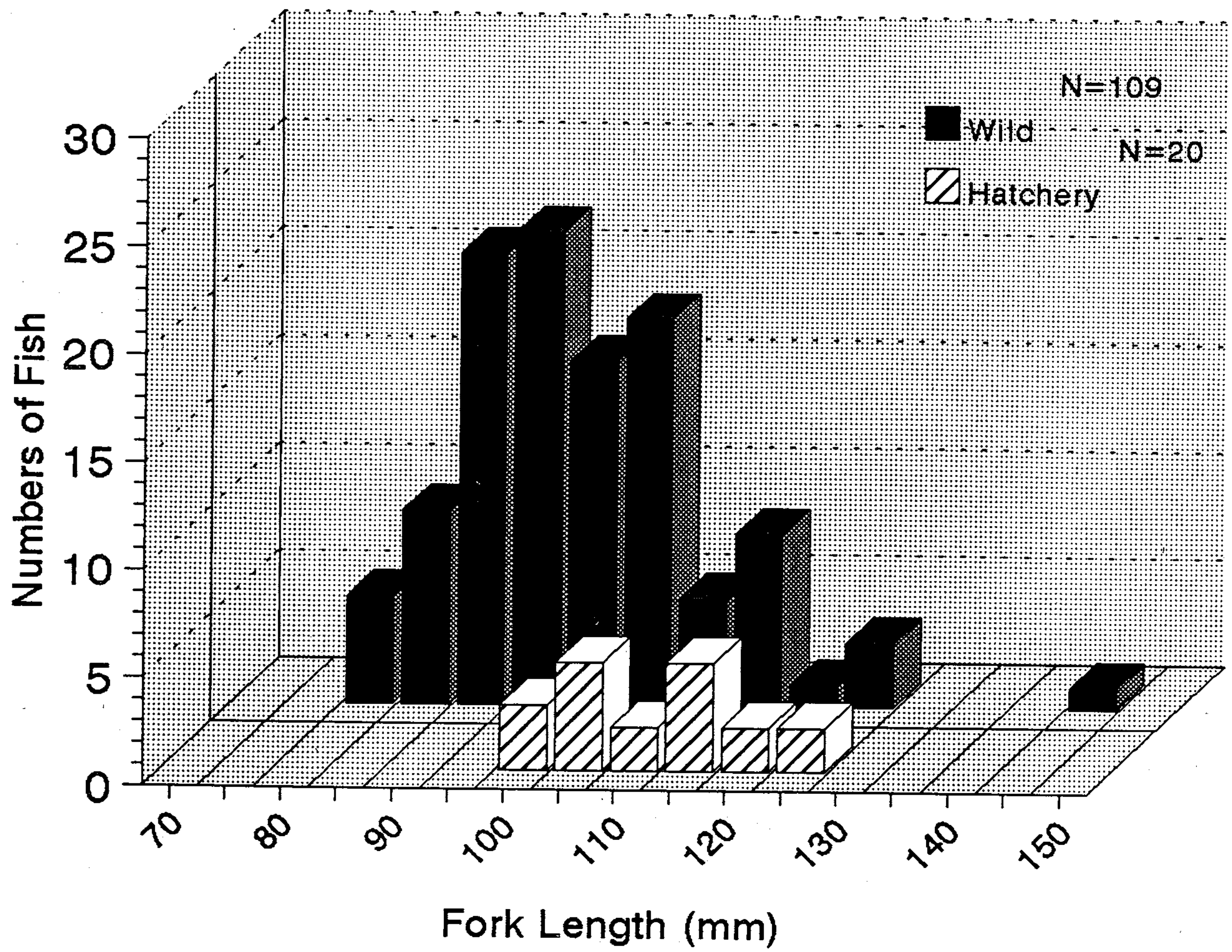


Figure 6. Length-frequency distribution of wild and hatchery-produced outmigrants captured at the Redfish Lake Creek trap in 1995.

Table 10. Cumulative interrogation numbers and median travel times of wild and hatchery-produced *O. nerka* detected at downstream dams between April 19 and October 31, 1995.

Origin and Release Date[a]	Broodstock Lineage[b]	Total Number of Interrogations and Median Travel Times (d) to Dams[c] GRJ	GOJ	LMJ	MCJ
Wild 4/19-6/15/95		9 (10.7)	14 (14.7)	11 (13.8)	8 (16.1)
Redfish Lake Net Pens 8/3/94[d]	OM91xAN93	11 (5.5)	11 (8.0)	9 (10.0)	1 (NA)
	AN93xAN93	4 (5.0)	8 (9.0)	6 (17.0)	2 (NA)
	OM91xOM91	1 (5.0)	0 (0)	0 (0)	0 (0)
	BY91xBY91	0 (0)	0 (0)	0 (0)	0 (0)
Direct to Redfish Lake 11/23/94[d]	BY91xBY91	4 (NA)	2 (NA)	3 (NA)	1 (NA)
Direct to Redfish Lake Creek 4/21/95[e]	BY91xBY91	29 (23.5)	11 (38.8)	27 (30.7)	4 (46.7)
	OM91xAN93	29 (39.4)	10 (54.5)	12 (54.7)	1 (45.0)
	AN93xAN93	13 (41.5)	1 (71.0)	5 (54.0)	1 (48.1)
Direct to Redfish Lake 6/29/95[e]	OM91xBY91	44 (8.5)	21 (17.3)	5 (15.4)	0 (0)
	BY91xBY91	39 (8.4)	15 (18.3)	5 (22.2)	3 (34.0)

[a] Sub-yearling fish (age 0+) released to all strategies except the direct to Redfish Lake Creek (4/21/95) release. The latter consisted of age 1+ smolt-age fish.

[b] OM91xAN93 refers to brood year 1993 progeny of female Redfish Lake outmigrant smolts collected in 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.

AN93xAN93 refers to brood year 1993 progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993.

OM91xOM91 refers to brood year 1993 progeny of Redfish Lake outmigrant smolts collected in 1991.

BY91xBY91 refers to second generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991. Fish released to Redfish Lake net pens (8/3/94) were produced in brood year 1993. Direct to Redfish Lake (11/23/94), and direct to Redfish Lake Creek (4/21/95) fish were produced in brood year 1993.5. Fish released direct to Redfish Lake on 6/29/95 were produced in brood year 1994.

OM91xBY91 refers to brood year 1994 progeny of female Redfish Lake outmigrant smolts collected in 1991 and first generation, male progeny of the four sockeye salmon that returned to Redfish Lake Creek in 1991.

Table 10. Continued

[c] GRJ, GOJ, LMJ, and MCJ refer to Lower Granite, Little Goose, Lower Monumental, and McNary dams.

[d] Travel times for net pen and direct to Redfish Lake (11/23/94) release strategies were calculated using interrogation data from Redfish Lake Creek trap and from specific dams for individual fish detected at both locations. Numbers of fish listed above reflect the total number of interrogations by dam and not the number of fish detected at both locations. Travel times listed for fish from these two release strategies were calculated using fewer interrogations than listed. Where "NA" is indicated for travel time, no individuals were detected at the Redfish Lake trap .

[e] Travel times listed for fish from the direct to Redfish Lake Creek (4/21/95) and the direct to Redfish Lake (6/29/95) release strategies were calculated using the full number of interrogations indicated above. Travel times for the 6/29/95 direct to Redfish Lake release group were calculated from their date of release to the lake and not from their date of interrogation at the Redfish Lake Creek trap. The trap was removed from operation on June 16, 1995 - prior to the release of these fish.

Table 11. PIT tag interrogation data collected in 1995 at Redfish Lake Creek trap (RLCTRP) and mainstem Snake and Columbia River dams for wild and hatchery-produced juvenile *O. nerka* . No. = number.

Release Strategy	Broodstock Lineage[a]	Release Date	Number Released	Number PIT-Tagged[f]	Estimated No. PIT-Tagged Past RLCTRP[g]	Cumulative Unique Interrogations[h]	Percent of Estimated No. PIT-Tagged Past RLCTRP[i]	Percent of Number PIT-Tagged[j]
Redfish Lake Net Pens	OM91xAN93[b]	8/3/94	9,337	854	62	17	27.4	2.0
	AN93xAN93[b]	8/3/94	1,610	837	30	13	43.3	1.6
	BY91xBY91[b]	8/3/94	152	152	0	0	0.0	0.0
	OM91xOM91[b]	8/3/94	31	31	4	1	25.0	3.2
	TOTAL	8/3/94	11,130	1,874	96	31	32.3	1.7
Direct to Redfish Lake	BY91xBY91[c]	11/23/94	2,989	854	6	7	100.0	0.8
Direct to Redfish Lake Creek	BY91xBY91[d]	4/21/95	3,277	854	854[k]	45	5.3	5.3
	OM91xAN93[d]	4/21/95	346	346	346[k]	42	12.1	12.1
	AN93xAN93[d]	4/21/95	171	171	171[k]	18	10.5	10.5
	TOTAL	4/21/95	3,794	1,371	1,371[k]	105	7.7	7.7
Direct to Redfish Lake	OM91xBY91[e]	6/29/95	15,585	882	na[l]	58	na[l]	6.6
	BY91xBY91[e]	6/29/95	11,594	849	na[l]	46	na[l]	5.4
	TOTAL	6/29/95	27,179	1,731	na[l]	104	na[l]	6.0
Wild	Wild	1995	109[m]	109	109[n]	27	100.0	24.8

Table 11. Continued

[a] OM91xAN93 refers to progeny of female Redfish Lake outmigrant smolts collected in 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.
AN93xAN93 refers to progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993.
BY91xBY91 refers to second generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.
OM91xOM91 refers to progeny of Redfish Lake outmigrant smolts collected in 1991.
OM91xBY91 refers to progeny of female Redfish Lake outmigrant smolts collected in 1991 and first generation male progeny of the four sockeye salmon that returned to Redfish Lake Creek in 1991.

[b] Sub-yearling releases from brood year 1993.

[c] Sub-yearling releases from brood year 1993.5.

[d] Yearling releases from brood year 1993.5.

[e] Sub-yearling releases from brood year 1994.

f The number of PIT-tagged fish in included in the "number released" column.

[g] Estimated number of PIT-tagged hatchery-produced juvenile sockeye salmon smolts emigrating past the outmigrant trap on Redfish Lake Creek between April 19 and June 15, 1995.

[h] Cumulative, first interrogations of individual fish between Lower Granite and McNary dams, April 19 - October 31, 1995.

[i] "Cumulative unique interrogations" divided by the "estimated no. PIT-tagged past RLCTRP".

[j] "Cumulative, unique interrogations" divided by "number PIT-tagged".

[k] Fish released immediately downstream of RLCTRP. "Number released" = "number PIT-tagged".

[l] RLCTRP removed from operation on June 15, 1995. Planting date for this group (June 29,1995) occurred after the date the trap was removed eliminating our ability to estimate outmigration past RLCTRP.

[m] Actual number trapped.

[n] Actual number PIT-tagged and released.

represented) release groups (Table 12). Wild outmigrant arrival timing at Lower Granite Dam was significantly different from the arrival timing of outmigrants from the November 23, 1994 direct to Redfish Lake and June 29, 1995 direct to Redfish Lake release strategy groups, however (Table 12).

Hatchery-Produced Outmigrants - We estimated 823 hatchery-produced sockeye salmon (95% CI 49 to 1,601) outmigrated from Redfish Lake in 1995. We relied on wild fish recapture efficiencies to estimate outmigration as no hatchery outmigrants were released to estimate trapping efficiency (Table 8). The total number of hatchery-produced outmigrants (PIT-tagged and non-PIT-tagged) captured at the Redfish Lake Creek trap site was used to develop the estimate of total outmigration presented above. Outmigration estimates presented in Table 13 differ slightly and represent expansions based solely on PIT-tagged trap captures (761 total outmigrants vs 823). The latter method was used to facilitate the evaluation of outmigration performance by release strategy presented below. As for wild outmigrant interrogation data presented above, numbers of hatchery-produced interrogations reflect unique detections only and have not been adjusted for spill or turbine passage.

Approximately 19% (2,728 of 14,119) of the hatchery-produced juveniles planted to Redfish Lake in 1994 were implanted with PIT tags. During 1995 outmigrant trapping, 28 of the 219 (12.8%) outmigrants captured at the Redfish Lake Creek trap possessed PIT tags. Information collected from these individuals represents our only ability to associate outmigration with release strategy and broodstock lineage (Table 13). Non-PIT-tagged outmigrants were adipose fin-clipped but could not be identified beyond "hatchery origin". In 1995, 26 of the 28 PIT-tagged trap captures (92.9%) originated from the August 3, 1994 Redfish Lake net pen release strategy. Brood year 1993 progeny of 1991 Redfish Lake outmigrant females and anadromous adult male sockeye salmon from return year 1993 (OM91xAN93) represented 17 of the 26 net pen outmigrant captures. Eight of the 26 were brood year 1993 progeny of the anadromous sockeye salmon from return year 1993 (AN93xAN93) and one trap capture was produced in brood year 1993 by outmigrant parents collected in 1991 as smolts (OM91xOM91). No PIT tag interrogations were recorded for second generation brood year 1993 progeny of the one female and three male sockeye salmon that returned to Redfish Lake in 1991 (BY91xBY91) (Table 13). We estimated approximately 6.6% of the fish from this release strategy emigrated from Redfish Lake and migrated past the monitoring trap on Redfish Lake Creek in 1995 (Table 13). Estimates of outmigration success for individual lineages within this release strategy ranged from 0.0% for BY91xBY91 progeny to 12.9% for OM91xOM91 progeny (Table 13).

Two of the 28 PIT-tagged trap captures (7.1%) originated from the November 23, 1994 direct to Redfish Lake release strategy (Table 13). These fish were second generation progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991 (BY91xBY91) and were produced from off-peak time spawning in brood year 1993.5. We estimated that approximately 0.7% of this release group outmigrated from Redfish Lake in 1995 (Table 13).

The mean fork length and weight of hatchery-produced outmigrants captured at the Redfish Lake Creek trap (average for all 28 PIT-tagged trap captures) was 113 mm and 12.9 g, respectively (fork length range=101 mm to 129 mm, weight range=9.4 g to 19.7 g), (Table 9).

Table 12. Comparison of 1995 arrival times at Lower Granite Dam for wild and hatchery-produced *O. nerka*. Table entries represent the results of multiple, two sample Kolmogorov-Smirnov tests for differences in distributions of arrival times (P=0.05).

Release Strategy	Redfish Lake Net Pens 8/3/94[a]	Direct to Redfish Lake 11/23/94[b]	Direct to Redfish Lake Creek 4/21/95[c]	Direct to Redfish Lake 6/29/95[d]
Wild 4/19-6/15/95	No Significant Difference	Significant Difference	No Significant Difference	Significant Difference
Redfish Lake Net Pens 8/3/94		No Significant Difference	Significant Difference	Significant Difference
Direct to Redfish Lake 11/23/94			No Significant Difference	Significant Difference
Direct to Redfish Lake Creek 4/21/95				Significant Difference

[a] No significant difference was found between arrival times at Lower Granite Dam for OM91xAN93 and AN93xAN93 net pen lineages and their arrival times were pooled for all comparisons presented above. OM91xOM91 and BY91xBY91 net pen lineages were dropped from comparisons due to inadequate sample size.

[b] Only one lineage represented in this release strategy: BY91xBY91.

[c] No significant difference was found between arrival times at Lower Granite Dam for OM91xAN93 and AN93xAN93 direct to Redfish Lake Creek lineages and their arrival times were pooled for all comparisons presented above. The BY91xBY91 component of this release strategy did, however, exhibit arrival times significantly different from the other two lineages within this release strategy as well as arrival times that were significantly from all other release strategy groups presented above. Table data represents the pooled lineage component only.

[d] No significant difference was found between arrival times at Lower Granite Dam for OM91xBY91 and BY91xBY91 direct to Redfish Lake lineages and their arrival times were pooled for all comparisons presented above. No other lineages were represented in this release strategy.

Table 13. PIT tag interrogation data collected in 1995 at Redfish Lake Creek trap (RLCTRP) for hatchery-produced juvenile sockeye salmon planted in Redfish Lake in 1994. No. = number.

Release Strategy	Broodstock Lineage[a]	Release Date	Number Released	Number PIT-Tagged[b]	Actual No. PIT-Tagged Past RLCTRP[c]	Estimated No. PIT-Tagged Past RLCTRP[d]	Estimated Total No. Past RLCTRP[e]	Percent of Release Past RLCTRP[f]
Redfish Lake Net Pens	OM91xAN93	8/3/94	9,337	854	17	62	678	7.3
	AN93xAN93	8/3/94	1,610	837	8	30	58	3.6
	BY91xBY91	8/3/94	152	152	0	0	0	0.0
	OM91xOM91	8/3/94	31	31	1	4	4	12.9
	TOTAL	8/3/94	11,130	1,874	26	96	740	6.6
Direct to Redfish Lake	BY91xBY91	11/23/94	2,989	854	2	6	21	0.7

[a] OM91xAN93 refers to brood year 1993 progeny of female Redfish Lake outmigrant smolts collected in 1991 and male sockeye salmon that returned to Redfish Lake Creek in 1993.
AN93xAN93 refers to brood year 1993 progeny of the two female and six male sockeye salmon that returned to Redfish Lake Creek in 1993.
BY91xBY91 (net pen release only) refers to second generation brood year 1993 progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.
BY91xBY91 (direct release only) refers to second generation brood year 1993.5 progeny of the one female and three male sockeye salmon that returned to Redfish Lake Creek in 1991.
OM91xOM91 refers to brood year 1993 progeny of Redfish Lake outmigrant smolts collected in 1991.

[b] The number of PIT-tagged fish is included in the "number released" column.

[c] Actual number of PIT-tagged broodstock program-produced juvenile sockeye salmon smolts captured at the Redfish Lake Creek outmigrant trap between April 19 and June 15, 1995.

[d] Estimated number of PIT-tagged broodstock program-produced juvenile sockeye salmon smolts emigrating past the outmigrant trap on Redfish Lake Creek between April 19 and June 15, 1995.

[e] Estimated total number of broodstock program-produced juvenile sockeye salmon smolts emigrating past the outmigrant trap on Redfish Lake Creek between April 19 and June 15, 1995.

[f] "Estimated total no. past RLCTRP" divided by "number released".

Based on PIT tag interrogations and estimates of trapping efficiency, we estimated that 96 and 6 PIT-tagged fish from the August 3, 1994 Redfish Lake net pen and November 23, 1994 direct to Redfish Lake release strategies outmigrated from Redfish Lake between April 19 and June 15 1995, respectively. Between April 19 and October 31 1995, 31 cumulative, unique PIT tag interrogations were recorded for the net pen release strategy between Lower Granite and McNary dams yielding a cumulative, unique interrogation rate of 32.3% (Table 11). Thirty-one cumulative, unique interrogations at the mainstem dams, however, represents only 1.7% of the original number of PIT-tagged fish (1,874) released to Redfish Lake from net pens. Broken down by lineage, cumulative, unique interrogation rates from time of release to detection at the dams ranged from 0.0% for the BY91xBY91 component to 3.2% for the OM91xOM91 component (Table 11). Individuals from this release strategy averaged between 5.0 d and 5.5 d to reach Lower Granite Dam from the time they were released (following interrogation) at the Redfish Lake Creek trap (Table 10). Seven cumulative, unique PIT tag interrogations were recorded for the November direct to Redfish Lake release strategy between Lower Granite and McNary dams yielding a cumulative, unique interrogation rate in excess of 100% (e.g., 6 PIT-tagged fish estimated to have outmigrated from Redfish Lake, yet 7 unique interrogations recorded at mainstem dams). Small sample size and reliance on trapping efficiency expansions at the Redfish Lake Creek trap are most likely responsible for this inconsistency. No estimate of travel time to Lower Granite Dam was made for this strategy as no unique fish were detected at both the Redfish Lake Creek trap and mainstem dam interrogation sites (Table 10).

The Redfish Creek outmigrant trap data for hatchery-produced juvenile sockeye salmon presented above represents the two Redfish Lake release strategies utilized in 1994. In all cases, outmigrants were released as age 0+ pre-smolts and were captured between April 19 and June 15, 1995 as age 1+ smolts after spending one winter in the lake (Table 2).

In 1995, fish produced in brood year 1994 were released to Redfish Lake over four release strategies (Table 3). Two of these strategies produced juvenile outmigrants and downstream PIT tag interrogations that same year and are considered in this report. One hundred five of the 1,371 (7.7%) PIT-tagged, age 1+ sockeye salmon released directly to Redfish Lake Creek downstream of the outmigrant trap on April 21, 1995 were interrogated between Lower Granite and McNary dams (Table 11). Detection success by lineage for this release strategy ranged from 5.3% for BY91xBY91 progeny to 12.1% for OM91xAN93 progeny (Table 11). Median travel times to Lower Granite Dam ranged from 23.5 d for BY91xBY91 progeny to 41.5 d for AN93xAN93 progeny (Table 10).

One hundred four of the 1,731 (6.0%) PIT-tagged, age 0+ sockeye salmon released directly to Redfish Lake on June 29, 1995 were also detected between Lower Granite and McNary dams (Table 11). PIT tag detections by lineage for this release strategy ranged from 5.4% for second generation progeny of the four anadromous adult returns from 1991 (BY91xBY91) to 6.6% for progeny of female Redfish Lake outmigrant smolts captured in 1991 and first generation male progeny of the four anadromous adult returns from 1991 (OM91xBY91) (Table 11). Median travel times to Lower Granite Dam averaged 8.4 d for BY91xBY91 progeny and 8.5 d for OM91xBY91 progeny (Table 10). These times reflect time taken to reach Lower Granite Dam from the date of release and not from recapture dates at the Redfish Lake trap.

No outmigration data were generated for either of these 1995 release groups at the Redfish Lake Creek trap. This stands to reason for the direct-creek, smolt-age release group as they were released downstream of the trap (denied access back to Redfish Lake). An unknown percentage of the age 0+ fish released to the lake on June 29, however, outmigrated past the trap site after we had disassembled it for the 1995 migration season (no further outmigration of wild or hatchery-produced fish from 1994 releases was occurring). We fully anticipated fish from this direct-lake release strategy would over-winter and outmigrate as age 1+ smolts in 1996.

The results of two sample Kolmogorov-Smirnov tests for differences in distributions of arrival times at Lower Granite Dam for hatchery-produced sockeye salmon are presented in Table 12. As mentioned above, outmigrants from the August 3, 1994 Redfish Lake net pen release strategy and two of the three lineages represented in the April 21, 1995 direct to Redfish Lake Creek release strategy arrived at Lower Granite Dam at approximately the same time. The BY91xBY91 component of the direct to Redfish Lake Creek strategy was the exception arriving significantly earlier than sockeye salmon from any other lineage or strategy interrogated between Lower Granite and McNary dams in 1995. Two of the four lineages represented in the net pen release (BY91xBY91 and OM91xOM91) were removed from arrival time comparisons due to inadequate sample size at mainstem dams. No significant difference in arrival times at Lower Granite Dam was observed between outmigrants from the Redfish Lake net pen and the November 23, 1994 direct to Redfish Lake release strategies. The only other overlap in arrival times occurred between the November 23, 1994 direct to Redfish Lake and April 21, 1995 direct to Redfish Lake Creek release strategies. Outmigrants from the June 29, 1995 direct to Redfish Lake release strategy arrived significantly later than sockeye salmon from any other lineage or release strategy interrogated at the dams in 1995.

Upper Salmon River

We trapped a total of seven *O. nerka* at the Sawtooth FH outmigrant trap between May 21 and May 30, 1995. Trap captures most likely outmigrated from Alturas Lake although Pettit Lake remains a potential source location. The mean fork length of *O. nerka* outmigrants was 81 mm (range 68 mm to 85 mm). Fish weight was not recorded and no attempt to age outmigrants was made. In 1995, no trapping-, handling- or PIT tagging- related mortalities occurred.

Because of the low number of *O. nerka* intercepted at the Sawtooth FH trap, the seasonal trap efficiency estimate for wild spring/summer chinook salmon (5.2%) was used to estimate *O. nerka* run size (Kiefer and Lockhart, 1996). Based on this efficiency, we estimated 1995 *O. nerka* run size at 135 fish. We did not attempt to calculate confidence intervals around this estimate.

None of the seven PIT-tagged outmigrants released from the Sawtooth FH trap were intercepted in 1995 at any of the downstream dam projects with detection capabilities.

Outmigrant Evaluations

We compared unique PIT tag interrogations (a relative measure of outmigration success) at Redfish Lake Creek trap and at mainstem dams using chi-square goodness of fit tests

($\alpha = 0.10$). Because broodstock lineages were not equally represented across all release strategies, no comparisons of outmigrant detection success by lineage, among strategies were made. Similarly, no comparisons of outmigrant detection success by lineage, within strategy were made for this first year of evaluations. Test results presented below represent comparisons of wild and hatchery-produced outmigrant detection success by release strategy. Individual broodstock lineages were pooled by release strategy to facilitate comparisons and to satisfy test requirements related to expected frequency cell size.

Redfish Lake Creek Trap

Brood year 1993 progeny from the August 3, 1994 net pen release strategy produced significantly greater interrogations at the Redfish Lake Creek trap than brood year 1993.5 progeny from the November 23, 1994 direct release to Redfish Lake release strategy ($X^2 = 6.58$, $P < 0.0103$), (Table 14). Twenty-six interrogations from the net pen group were recorded at the trap from an original release of 1,874 PIT-tagged individuals. Two of the 854 PIT-tagged fish from the fall direct lake release were interrogated passing the Redfish Lake trap. No other comparisons were made for this location in 1995.

Table 14. Chi-square goodness of fit comparison ($\alpha = 0.10$) of interrogations for hatchery-produced sockeye salmon smolts. Comparison is by release strategy for smolts interrogated at the Redfish Lake Creek trap site between April 19 and June 15, 1995.

Release Strategy[a]	Date Released	Number PIT-Tagged	Interrogations	X^2	P	Outcome
Redfish Lake Net Pens	8/3/94	1,874	26			
				6.58	<0.0103	Significantly greater interrogations for 8/3/94 Redfish Lake Net Pen release group.
Direct to Redfish Lake	11/21/94	854	2			

[a] Individual broodstock lineages reviewed in Table 2 were pooled by release strategy for this comparison.

Mainstem Snake and Columbia River Dams

We detected no significant difference in the number of cumulative, unique interrogations for hatchery-produced progeny released to Redfish Lake from the two strategies employed in 1994 ($\chi^2=2.39$, $P<0.120$). Age 1+ outmigrants from the August 3, 1994 net pen release strategy produced 31 detections from an initial release of 1,874 PIT-tagged (1.7%) fish while 7 interrogations from an initial release of 854 PIT-tagged individuals (0.8%) were recorded for age 1+ outmigrants from the November 23, 1994 direct to Redfish Lake release strategy, (Table 15).

Wild outmigrants produced a significantly greater cumulative, unique interrogation rate than sockeye salmon from any of the release strategies employed in 1994 or 1995 and detected between April 19 and October 31, 1995. Chi-square and *P* values ranged from 34.32 ($P<0.0001$) to 185.92 ($P<0.0001$) for age 1+ hatchery-produced progeny from the April 21, 1995 direct to Redfish Lake Creek (brood year 1993.5) and August 3, 1994 Redfish Lake net pen (brood year 1993) release strategies, respectively (Table 15).

With the exception of the wild outmigrants, age 1+ progeny from the April 21, 1995 direct to Redfish Lake Creek release strategy produced significantly greater detections (105 interrogations from an initial release of 1,371 PIT-tagged fish) than sockeye salmon from any of the broodstock program release strategies employed in 1994 and 1995 and detected between Lower Granite and McNary dams between April 19 and October 31, 1995 (Table 15). The Age 0+ outmigrants from the June 29, 1995 direct to Redfish Lake release strategy produced the next highest rate of detection (104 interrogations from an initial release of 1,731 PIT-tagged fish). Although similar, test statistics for these two release groups were still significantly different ($\chi^2=3.06$, $P<0.080$) (Table 15).

Brood year 1994 age 0+ outmigrants from the June 29, 1995 direct to Redfish Lake release strategy were interrogated at a significantly higher rate than brood year 1993 age 1+ progeny from the August 3, 1994 Redfish Lake net pen and brood year 1993.5 November 23, 1994 direct to Redfish Lake release strategies ($\chi^2=46.12$, $P<0.0001$ and $\chi^2=36.21$, $P<0.0001$, respectively).

Volitional Spawning Investigations

Eleven of 34 adult broodstock sockeye salmon planted to Redfish Lake in 1994 and fitted with ultrasonic transmitters were still active at the end of the 1994 tracking season (November 22, 1994). In 1995, we determined the position of five of these transmitters between June 21 and September 21 but no movement was observed. The remaining six transmitters were not located during the 1995 tracking effort (Table 16). Telemetry data collected in 1995 suggest none of the 11 broodstock adults active at the termination of 1994 telemetry efforts successfully over-wintered (assuming no transmitter shedding). As no broodstock adults were planted in Redfish Lake in 1995, no additional telemetry data were collected.

Table 15. Chi-square goodness of fit comparisons ($\alpha = 0.10$) of cumulative, unique interrogations for wild and hatchery-produced *O. nerka* smolts. Comparisons are by release strategy for smolts interrogated at juvenile fish bypass systems of Lower Granite, Little Goose, Lower Monumental, and McNary dams between April 19 and October 31, 1995.

Release Strategy[a]	Date Released	Number PIT-Tagged	Cumulative Unique Interrogations[b]	X^2	P	Outcome
Redfish Lake Net Pens	8/3/94	1,874	31	2.39	<0.12	No significant difference in cumulative, unique interrogations between release groups. Power = .50
Direct to Redfish Lake	11/23/94	854	7			
Redfish Lake Net Pens	8/3/94	1,874	31	69.60	<0.0001	Significantly greater cumulative, unique interrogations for 4/21/95 Direct to Redfish Lake Creek release group.
Direct to Redfish Lake Creek	4/21/95	1,371	105			
Redfish Lake Net Pens	8/3/94	1,874	31	46.12	<0.0001	Significantly greater cumulative, unique interrogations for 6/29/95 Direct to Redfish Lake release group.
Direct to Redfish Lake	6/29/95	1,731	104			
Direct to Redfish Lake	11/23/94	854	7	36.21	<0.0001	Significantly greater cumulative, unique interrogations for 6/29/95 Direct to Redfish Lake release group.
Direct to Redfish Lake	6/29/95	1,731	104			

Table 15. Continued.

Release Strategy[a]	Date Released	Number PIT-Tagged	Cumulative Unique Interrogations[b]	X^2	P	Outcome
Direct to Redfish Lake	11/23/94	854	7	50.07	<0.0001	Significantly greater cumulative, unique interrogations for 4/21/95 Direct to Redfish Lake Creek release group.
Direct to Redfish Lake Creek	4/21/95	1,371	105			
Direct to Redfish Lake Creek	4/21/95	1,371	105	3.06	<0.080	Significantly greater cumulative, unique interrogations for 4/21/95 Direct to Redfish Lake Creek release group.
Direct to Redfish Lake	6/29/95	1,731	104			
Wild Redfish Lake Outmigrants	1995	109	27	185.92	<0.0001	Significantly greater cumulative, unique interrogations for 1995 Wild Redfish Lake outmigrants.
Redfish Lake Net Pens	8/3/94	1,874	31			
Wild Redfish Lake Outmigrants	1995	109	27	155.84	<0.0001	Significantly greater cumulative, unique interrogations for 1995 Wild Redfish Lake outmigrants.
Direct to Redfish Lake	11/23/94	854	7			

Table 15. Continued.

Release Strategy[a]	Date Released	Number PIT-Tagged	Cumulative Unique Interrogations[b]	X^2	P	Outcome
Wild Redfish Lake Outmigrants	1995	109	27			
				34.32	<0.0001	Significantly greater cumulative, unique interrogations for 1995 Wild Redfish Lake outmigrants.
Direct to Redfish Lake Creek	4/21/95	1,371	105			
Wild Redfish Lake Outmigrants	1995	109	27			
				51.79	<0.0001	Significantly greater cumulative, unique interrogations for 1995 Wild Redfish Lake outmigrants.
Direct to Redfish Lake	6/29/95	1,731	104			

[a] Individual broodstock lineages reviewed in Tables 2 and 3 were pooled by release strategy for these comparisons.
[b] Cumulative, first interrogations of individual fish between Lower Granite and McNary dams.

Table 16. Final 1995 tracking status of 11 ultrasonic-tagged, adult sockeye salmon active at the end of the 1994 tracking effort.

Tag Frequency[a]	Lineage[b]	Status[c]
266	OM91	Stationary
366	OM91	Stationary
473	OM91	Stationary
2354	OM91	Stationary
2363	OM91	Stationary
97	OM91	Absent
2237	OM91	Absent
2543	OM91	Absent
555	BY91	Absent
10-6	BY91	Absent
365	BY91	Absent

[a] Frequency of the ultrasonic transmitter implanted in the fish.

[b] OM91 = 1991 Redfish Lake outmigrants reared to sexual maturity at Eagle FH.
BY91 = progeny of 1991 anadromous adults reared to sexual maturity at Eagle FH.

[c] Absent = transmitter signal no longer audible.
Stationary = transmitter signal audible but not moving.

Predator Investigations

Alturas Lake Tributaries

No redds or adult bull trout were observed in Alturas Lake Creek between Alturas Lake and Alpine Creek. We observed three bull trout redds and one possible test redd in Alturas Lake Creek upstream of its confluence with Alpine Creek. All redds appeared to be recently constructed. Low stream discharge upstream of the location where we observed redds appeared to restrict adult access. We did not observe adult bull trout in this section of the stream.

We observed five redds and five partial or test redds in Alpine Creek upstream of its confluence with Alturas Lake Creek. Two pair of adult bull trout were observed on two of the five redds. We estimated the adult bull trout to be between 500 mm and 650 mm in fork length. The three unattended redds appeared to be recently constructed.

Within our survey sections, both Alturas and Alpine creeks had abundant, high quality spawning habit. Water temperature ranged from 5.0°C to 8.0°C on the date of our survey (09:00 hours to 13:00 hours). Overhanging riparian vegetation, under-cut banks, and large woody debris were not limiting.

Redfish Lake Tributary

We observed three possible bull trout redds and three test redds on Fishhook Creek. The three possible redds appeared to be recently constructed but were not well defined. Five adult bull trout were observed in the survey stream section, none of which were associated with redds. We estimated these individuals to be between 425 mm and 500 mm in fork length.

Fishhook Creek has abundant high quality spawning habitat in the upper reaches of the area surveyed. The lower reach (approximately 1.0 km) has steeper gradient and larger substrate. Stream temperature remained constant at 8.0°C on the afternoon of the survey (14:00 hours to 18:00 hours). Overhanging riparian vegetation, under-cut banks and large woody debris were very available.

Parental Lineage Investigations

Otolith samples from brood year 1993 and broodyear 1994 broodstock progeny analyzed in 1995 represent known life history. All samples were collected from progeny of the two and one anadromous adult female sockeye salmon that returned to Redfish Lake Creek in 1993 and 1994, respectively. Individual site Sr/Ca ratios from otolith nuclei of brood year 1993 progeny ranged from 0.0008 to 0.0021. Mean Sr/Ca ratios (N=20) ranged from 0.0010 to 0.0019 (CV 0.04 to 0.10), (Figure 7; Appendix D). Ninety-five percent of the mean Sr/Ca ratios (19 of 20 samples) were greater than or equal to 0.0014.

Individual site Sr/Ca ratios from otolith nuclei of brood year 1994 progeny ranged from 0.0014 to 0.0026. Mean Sr/Ca ratios (N=43) ranged from 0.0017 to 0.0021 (CV 0.02 to 0.11) (Figure 7, Appendix D).

Individual site Sr/Ca ratios from otolith nuclei of 1995 male Fishhook Creek kokanee spawners ranged from 0.0003 to 0.0008. Mean Sr/Ca ratios (N=21) ranged from 0.0005 to 0.0006 (CV 0.09 to 0.32) (Figure 7, Appendix D).

Redfish Lake Kokanee Fishery Investigation

Anglers fished an estimated 2,554 (±773) h from July 15 through July 31 (Table 17). Boat angling and bank angling represented 77% and 23% of the total estimated effort, respectively. Anglers averaged 1.97 h each, per fishing trip. The overall catch rate for all species (fish harvested and released) was 0.17 fish/h (Table 18). The overall catch rate for kokanee was 0.15 fish/h (0.11 fish/h harvested and 0.04 fish/h released). The overall catch rate for bull trout was 0.02 fish/h.

Anglers caught an estimated 481 (±294) fish (all species) during the fishery. The estimated number of fish (all species) harvested and released was 309 (±217) and 172 (±130), respectively. The estimated number of kokanee harvested during the fishery was 306 (±216). Anglers caught and released approximately 134 kokanee during the

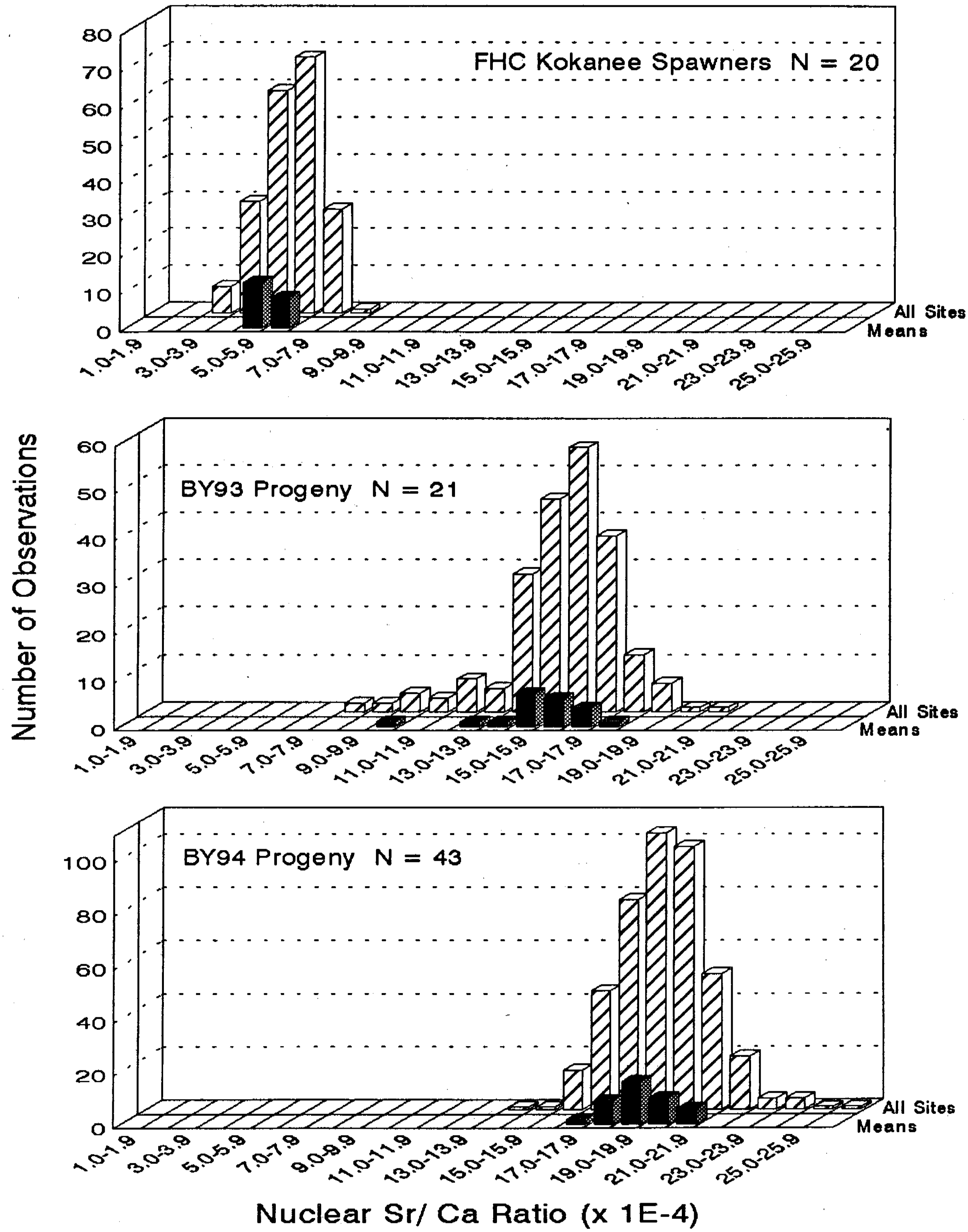


Figure 7. Frequency distributions of individual sites and mean Sr/Ca ratios measured in sagittal otolith nuclei from Redfish Lake *O. nerka* with different life histories. FHC = Fishhook Creek adult kokanee spawners collected in 1995, BY 93 = progeny of 1993 adult anadromous female sockeye salmon, and BY 94 = progeny of 1994 adult anadromous female sockeye salmon.

Table 17. Creel survey data summary for 1995 Redfish Lake kokanee fishery (No. = number of fish, Cr = catch rate in number of fish/h).

Day Type	Angler Type	Hours Fished	Estimated Total No. of Fish Caught No.	Cr	Kept No.	Cr	Released No.	Cr	Estimated Total No. of Kokanee Caught No.	Cr	Kept No.	Cr	Released No.	Cr	Estimated Total No. of Bull Trout Caught No.	Cr	Kept No.	Cr	Released No.	Cr
Weekend																				
	Boat	772																		
	Bank	160																		
	Total	932	324	0.35	197	0.21	127	0.14	279	0.33	194	0.21	85	0.12	8	0.02	3	0.00	5	0.02
Weekday																				
	Boat	1,210																		
	Bank	412																		
	Total	1,622	157	0.10	112	0.07	45	0.03	161	0.08	112	0.07	49	0.01	33	0.02	11	0.01	22	0.01
Grand Total		2,554	481	0.17	309	0.11	172	0.06	440	0.15	306	0.11	134	0.04	41	0.02	14	0.01	27	0.01

Table 18. Redfish Lake estimated angler effort, kokanee harvest, and kokanee catch rate for 1986, 1987, and 1995 fisheries. Total kokanee caught includes harvest and release, Catch Rate = number of kokanee/h.

Year	Month	Total Hours Fished	Total Kokanee Caught	Catch Rate
1986 Totals		15,449	921	0.06
	May[a]	2,208	22	0.01
	June	4,530	363	0.08
	July	5,177	465	0.09
	August	3,534	71	0.02
1987 Totals		12,507	1,878	0.15
	May[b]	907	90	0.10
	June	3,170	1,280	0.40
	July	4,289	480	0.11
	August	3,509	7	0.01
	September[c]	632	21	0.03
1995 Totals[d]		2,554	440	0.15

[a] May 24 through May 31.

[b] May 23 through May 31.

[c] September 1 through September 7.

[d] July 15 through July 31.

1995 fishery. Anglers releasing kokanee did not indicate any difficulty associated with this task. In fact, many anglers reported kokanee "shaking off" prior to landing. Information collected during interviews indicated anglers also felt fish were being released unharmed. The majority of anglers used artificial lures with single or treble barbed hooks.

DISCUSSION

Total Population, Density, and Biomass Estimation

Midwater trawl data from 1995 represents the sixth consecutive year of IDFG Stanley Basin sockeye salmon investigations. Data collected from these efforts has increased our understanding of the degree of natural variability expressed by the kokanee/sockeye salmon populations in the various Basin lakes. As juvenile sockeye salmon supplementation from the captive broodstock program increases (1997 and 1998 supplementation is expected to exceed 500,000 eyed-eggs for both years from IDFG and NMFS broodstock facilities), these data will become increasingly important as indicators of community structure and stability. In addition, these data provide valuable guidelines for the development of broodstock program release strategies.

Redfish Lake

September estimates of the total *O. nerka* population and density in Redfish Lake have increased by over two-fold since 1990, the first year of investigation. September 1995 *O. nerka* population and density estimates increased by approximately 20% over September estimates from the previous year. As only one hatchery-produced juvenile sockeye salmon was captured in the September 1995 trawl, this increase primarily reflects greater numbers of kokanee or residual sockeye salmon. The total September, Redfish Lake *O. nerka* biomass or standing crop increased from 1.30 kg/hectare in 1990 to 6.51 kg/hectare in 1995. Between 1990 and 1994, this trend was present but represented an increase of only 62% (1.30 kg/hectare to 2.11 kg/hectare). Between September 1994 and 1995 trawls, the total estimated biomass increased by just over 200%. The majority of this increase was due to greater numbers of age 2+ fish captured in the September 1995 trawl, although increases in mean weight for each age-class contributed to the higher 1995 biomass estimate.

In spite of the observed increase in all measured *O. nerka* population parameters in 1995, we have yet to observe a decline in growth rates in Redfish Lake. Ricker (1937) suggested that (for sockeye salmon) little density dependent effect is visible until an upper threshold density is reached. Similar findings were reported by Goodlad et al. (1974) and McDonald and Hume (1984). Rieman and Meyers (1990), however, reported that density-dependent growth in kokanee is different than in sockeye salmon, and a threshold effect probably does not occur in older age-classes. They concluded that large changes in growth are most evident in populations fluctuating around relatively low densities or exhibiting rapid growth in number.

Prior to 1995, we observed very little variation in length or weight among Redfish Lake year-classes. The increase observed in 1995 may have been influenced by first year efforts of a whole-lake fertilization program conducted by the SBT as part of the Sawtooth Valley Project. The primary objectives of the fertilization effort are to maximize Redfish Lake nursery conditions by increasing zooplankton densities and biomass and to maintain lake carrying capacities at levels adequate to accommodate broodstock program supplementation. Activities and findings related to this program are the reporting responsibility of the SBT and will appear under separate cover.

Past Redfish Lake trawls have been largely unsuccessful at capturing juvenile outplants from the captive broodstock program. Zero, zero, and one hatchery juvenile were collected during September 1994, June 1995 and September 1996 trawl surveys, respectively. While time from fish plants to trawl dates and the size of the fish plants varies for these three examples, it follows that hatchery-produced outplants should have been sampled if they were mixing uniformly with the lake's wild population. The proportion of hatchery-produced to wild *O. nerka* was great enough, in each case, to have produced hatchery fish in all three trawl samples just by chance if mixing was occurring. Outmigration data collected in the spring of 1996 will provide more information on survival of 1995 supplementation groups.

Following the release to Redfish Lake of 55,866 hatchery-produced sub-yearling sockeye salmon on October 5 and 10, 1995, midwater trawling was conducted on October 24 to assess the status (distribution and abundance) of these recent release groups. Six of the 22 *O. nerka* sampled during this survey were of hatchery origin (27%). Hatchery fish appeared to be distributed evenly with wild fish as equal numbers were captured in each of the three trawl transects surveyed. Wild *O. nerka* abundance estimated from the October survey was 41% of the September abundance estimate (25,348 fish compared to 61,646 fish). This difference was most likely due to the weaker fish stratification we observed during the October trawl (fish were observed in shallow and deep water locations inaccessible to our trawl gear). If we assume only marginal natural mortality from September to October trawl dates (equally affecting hatchery and wild components of the population) and expand the number of hatchery sockeye salmon estimated from the October trawl (9,505 fish) by the proportional difference observed between September and October wild *O. nerka* estimates, it is possible to derive an index of hatchery fish abundance. Performing this extrapolation yields an October hatchery fish population estimate of approximately 23,200 fish (9,505/0.41). Considering that trawl-based population estimates generally underestimate the true population by some degree (Parkinson et al. 1994), this number represents an October estimate of minimum abundance for hatchery-produced juvenile sockeye salmon. Results from hydroacoustic surveys conducted by the SBT during September and October trawl periods support our findings (similar decrease in fish abundance between September and October surveys).

Alturas Lake

Alturas Lake has exhibited more variability with respect to *O. nerka* population parameter estimates than any other Stanley Basin lake. September 1994 estimates of Alturas Lake total *O. nerka* population, density and biomass represent a decline of approximately 88% over fall estimates from 1993. In 1995, population numbers, fish density, and biomass increased by approximately 300%. Since the inception of Alturas Lake trawling in 1990, however, population and density estimates have declined by greater than 82%.

Juvenile *O. nerka* recruitment and adult escapement data for Alturas Lake have also exhibited considerable variability. This variability has resulted in the establishment of several years of incomplete age-class structure. Since 1992, as few as 62 (1992) and as many as 3,000 (1994) adults have escaped to Alturas Lake Creek to spawn (SBSTOC - October 1994). In 1995, an estimated 1,000 adult *O. nerka* escaped to Alturas Lake Creek (SBSTOC - September 1995). Since the inception of fry monitoring in 1992, *O. nerka* recruitment to Alturas Lake has ranged from an estimated 1,000 fish in 1993 to as many as 7,000 fish in 1992 (Teuscher and Taki 1994). In 1995, fry monitoring was hampered by high discharge preventing the development of a recruitment estimate (SBSTOC - May 1995).

Alturas Lake *O. nerka* growth beyond age 1 is the slowest we have documented for any of the Stanley Basin lakes supporting *O. nerka*. In September 1995, the mean weight of age 2+ Alturas Lake juveniles was 66% less than the mean weight of same age juveniles from Redfish Lake. In addition, adult spawners are generally one year older than spawners in Redfish, Pettit, and Stanley Lakes (age 4+ and 5+ as opposed to age 3+ and 4+).

Pettit Lake

September 1995 Pettit Lake *O. nerka* trawl estimates are roughly twenty-fold greater than estimates developed in 1992, the first year of Pettit Lake data collection. From September 1994 to September 1995, total population and density estimates increased from 14,743 fish and 128 fish/hectare to 59,002 fish and 513 fish/hectare, respectively (an increase of over 200%). Total biomass increased from 3.50 kg/hectare in 1992 to 20.75 kg/hectare in 1995. Greater than half of this increase was observed between September 1994 and 1995 trawl estimates. In 1995, age 2+ and 3+ fish comprised over 77% of the trawl catch and represented most of the observed shift in biomass. This trend of increasing abundance, density, and biomass has, to date, been accommodated by the lake's ability to produce food resources. In 1995, however, we observed minor reductions in mean fish length and weight for age-classes 1 and 3. In addition, we were not successful at capturing young-of-the-year during the September survey. Historically, Pettit Lake has displayed full age-class structure with relatively consistent fish size distribution. While we do not believe 1995 trawl data represents serious density-dependent growth compensation or year-class failure, we do feel it is now prudent to monitor the Pettit Lake community closely in the event that we are seeing the early signs of community collapse or set back. Where sockeye salmon nursery lake community collapse has been documented, zooplankton resources typically become so depressed by excessive planktivory that sockeye salmon rearing efficiency is reduced for several ensuing broods (Koenings and Burkett 1987; Koenings and Kyle 1994).

Pettit Lake is relatively productive in comparison to Redfish and Alturas lakes (Teuscher and Taki 1994). Comparatively fast growth is observed in most age-classes, the exception being the age 0+ component. Although no age 0+ fish were captured in the 1995 trawl, young-of-the-year captured in past trawls have been relatively small in comparison to Redfish and Alturas lake young-of-the-year. These data suggest the possibility of late emergence and recruitment to the limnetic community. In 1996, SBT biologists confirmed late spawn timing by capturing mature adults under the ice between January and April (SBSTOC - May 1996).

In 1995, Pettit Lake became the second nursery lake in the Stanley Basin to receive hatchery-produced juvenile sockeye salmon. Our September trawl occurred 62 d after the release of this group of 8,572 sub-yearling fish. Population parameter estimates discussed above reflect the lake's kokanee community as no hatchery-produced juvenile sockeye salmon were captured during the September survey.

Stanley Lake

Stanley Lake exhibits the lowest total population, density and biomass of the four Basin lakes investigated. Since the inception of Stanley Lake trawling in 1992, population variables have been estimated at consistently low levels. September 1995 total *O. nerka* population and density estimates decreased by approximately 62% from estimates made in September of 1994. The estimated *O. nerka* biomass decreased approximately 51% from the previous year. Biomass estimates for Stanley Lake are among the lowest in the State for oligotrophic waters supporting kokanee (Rieman and Meyers 1991).

Age 0+ and 1+ fish comprised 82% and 100% of the September 1995 and 1994 trawl samples, respectively. The absence of older age-classes in our trawl catch may reflect physical limitations encountered during sampling. The relatively shallow depth and small size of Stanley Lake requires that trawl transects be restricted to the center of the lake along one axis. In addition, only one step is generally fished for each transect due to the short axis length of the lake. Because of these limitations, older age-classes may be able to more effectively avoid our trawl gear. Stanley Lake is also the only Basin lake that supports lake trout. Older *O. nerka* are most likely limited by the presence of this predator (Teuscher and Taki 1994).

Sampling Limitations

Midwater trawling remains one the best methods of active sampling for obtaining information on population size, age, and size structure, and stock discrimination for limnetic species. However, several limitations associated with this methodology could affect the quality of the data. Trawling may not accurately reflect all size classes within the targeted population. Rieman (1992) suggests that trawling at speeds of approximately 1 m/s yield reliable estimates of abundance for fish between 50 mm and 220 mm in length. Small individuals (<50 mm) may not be fully represented in the trawl as they might pass through the mesh and avoid capture. Conversely, large individuals (>220 mm) might simply avoid the net, particularly as it is being retrieved. The significance of this potential limitation as it relates to our data is unknown.

Time of year selected for trawling might also bias data. With respect to Idaho waters, kokanee stocks in Redfish and Alturas lakes are characterized as "early spawning". Stanley Lake supports primarily early stream spawners, however, a small stock of "late spawning" *O. nerka* has been identified. Pettit Lake supports late lake spawning kokanee. Early stream spawners are generally absent from nursery lakes as early as the beginning of August. Naturally, the majority of these individuals are lost to the trawl once they begin their migration into lake tributaries. Emergent fry generally recruit to the lake between late April and July. There is some question as to when these fish are fully recruited to the limnetic community. Spring trawling will potentially sample older age-classes yet under sample the not-yet-recruited age 0+ component. Fall sampling will not capture older age-classes lost to early spawning but will more accurately reflect numbers of recently recruited age 0+ fish. Biomass estimates will also vary by time of year sampled. Late season or fall sampling will reflect fish condition at the end of the growing season (e.g., greater biomass). Fall trawl dates will also take advantage of the time of year when *O. nerka* patterns of vertical distribution are relatively narrow. In most cases, except where noted, our data reflect late August through late September (fall) sampling.

Trawl estimates of population and density improve with increasing precision. To achieve reliable estimates of number and density of fish by age-class, multiple trawl transects are generally required. Rieman (1992) suggests that a minimum of seven transects be employed whenever possible. In 1995, we fished between five and seven transects per lake, per night. Since the inception of trawling in 1990, we have made a concerted effort to fish the same transect locations and the same number of transects per lake per year.

Trawl estimates should not be accepted as true estimates of population number or density due to the aforementioned limitations. In general, trawl-based estimates represent some degree of underestimation of true population characteristics. Beginning in 1993, hydroacoustic estimates of Stanley Basin lake *O. nerka* populations were initiated by the SBT.

Hydroacoustic stock assessment can be used to complement population and density estimates developed from trawling. In the future, emphasis will be placed on comparing the effectiveness of both methods of stock assessment. In general, however, trawl and hydroacoustic-based estimates have reported similar population, density and biomass trends for all Stanley Basin lakes investigated.

Outmigrant Monitoring and Evaluation

Monitoring *O. nerka* outmigrant runs from Stanley Basin lakes plays an important roll in recovery efforts. As hatchery-produced progeny are outplanted to rear and migrate volitionally, outmigrant monitoring provides timely information on the relative success of the different components of our supplementation efforts. Information collected from outmigrant monitoring has contributed to our knowledge of outmigrant characteristics and provided genetic source material for continuing efforts to differentiate stocks. Outmigrant *O. nerka* captured between 1991 and 1993 represent a major production element within the broodstock program.

Redfish Lake

Wild Outmigrants - The number of wild *O. nerka* estimated to have outmigrated from Redfish Lake in 1995 decreased by approximately 80% from the 1994 estimate (357 outmigrants compared to 1,820). With the exception of the 1994 estimate, the trend in outmigration has been one of decline. Since the inception of trapping in 1991, estimates of outmigration have ranged from 4,500 fish in 1991 to 357 fish in 1995. The previous low year estimate was generated for 1993 when 569 wild *O. nerka* reportedly outmigrated from Redfish Lake (Kline 1994). As no anadromous sockeye salmon have spawned in Redfish Lake since 1989 (all returning adults have been taken into the captive broodstock program since 1991 and no fish returned in 1990), 1995 outmigrants are progeny of either the beach-spawning residual sockeye salmon or resident creek-spawning kokanee stocks of Redfish Lake. At the present time, we do not have conclusive information on what contributions are being made by residual sockeye salmon or resident kokanee with respect to the production of outmigrants. Mitochondrial DNA information generated from Redfish Lake outmigrants collected in 1991 through 1993 suggests (based on haplotypes) that the majority (90+%) of outmigrants resemble anadromous sockeye salmon. However, several of the haplotypes associated with the anadromous form are also shared by the resident kokanee stock (Brannon et al. 1994). The results of electrophoretic studies support these data and indicate that the vast majority of Redfish Lake outmigrants are genetically identical to their anadromous counterpart (SBSTOC - January 1992). If outmigrants are largely produced by residual beach-spawners, their numbers should remain depressed as fewer than 100 adults were estimated to have spawned in 1994 and 1995 (Teuscher and Taki 1995; 1996).

Efforts to enumerate outmigration from Stanley Basin lakes prior to 1991 are scarce. Between 1955 and 1966, Bjornn et al. (1968) operated a two-way weir on Redfish Lake Creek collecting information on adult escapement as well as juvenile outmigration. During this period, they observed a range in Redfish Lake outmigrant run size from 2,133 fish in 1960 to 65,000 fish in 1957. Estimates of outmigrant run size exceeded 20,000 fish in 7 of their 12 years of investigation. Bjornn et al. (1968) observed peak outmigration occurring the first three weeks of May. In 1995, we observed the largest numbers of fish leaving Redfish Lake during this same period. Outmigration data from 1991 through 1993 generally conform to this pattern as well (Kline 1994; Kline and Younk 1995).

Much has been written on the relationship between the age at which juvenile sockeye salmon migrate and their growth during their first summer in the nursery lake. Foerster (1969) noted that the number of sockeye salmon that remain in lakes for more than one year prior to moving seaward are not numerous in most of the prominent sockeye salmon rivers of British Columbia. In cases where age 2+ smolts are observed, the evidence suggests that the rate of growth is so slow that the young sockeye salmon are not sufficiently developed at the end of their first year to be stimulated to migrate to the ocean. Koenings and Burkett (1987) presented an empirical classification of sockeye salmon smolt production related to population characteristics for coastal and interior Alaskan lakes. They determined that sockeye salmon smolts from rearing-limited lake systems were frequently older and larger as a result of density dependent rearing conditions and remained in nursery lakes longer before outmigrating. Bjornn et al. (1968) reported that juvenile sockeye salmon migrated from Redfish Lake at the beginning of their second (age 1+) or third (age 2+) summer of life. During their period of investigation (1955 through 1966), the proportion of age 1+ smolts in the outmigration varied from 2% to 98%. They concluded that if population density was low and growth good, young salmon would likely outmigrate after one year of rearing (age 1+). If growth was unusually good, migration could be delayed. If growth was slow (e.g., due to high fish density), chances were increased the fish would remain in the lake a second year. Since 1991, rearing conditions in Redfish Lake have favored the production of age 1+ outmigrants. The greatest proportion of age 2+ outmigrants was recorded in 1992 when approximately 15% of the run consisted of this age-class (Kline 1994). We have not noticed the degree of variability in outmigration age reported by Bjornn et al. (1968).

Adult sockeye salmon escapement to Redfish Lake between 1955 and 1966 ranged from 11 fish in 1961 to 4,361 fish in 1955 (Bjornn et al 1968). Adult returns exceeded 300 fish in 6 of the 12 years investigated. In 1991, adult sockeye salmon access to Redfish Lake was circumvented by the installation of an upstream adult trap on Redfish Lake Creek, an integral component of the present recovery effort. Prior to 1991 and the commencement of the Sawtooth Valley Project, IDFG operated the trap infrequently and adult sockeye salmon escapement to the lake was possible. Based on adult detections at Lower Granite Dam, no sockeye salmon were believed to have reached Redfish Lake in 1990. In 1988 and 1989, 23 and 2 adult sockeye salmon were detected at Lower Granite Dam, respectively. Actual observations of sockeye salmon spawning in Redfish Lake for this period are scarce, however, it is likely that successful lake spawning did occur in 1988 and 1989 (Hall-Griswold, 1990).

Relatively high cumulative, unique PIT tag interrogations were recorded in 1991 and 1993 at downstream Snake and Columbia River dams for wild Redfish Lake *O. nerka* smolts (57% and 44%, respectively). Detection rates recorded in 1992 and 1994 were lower (22% and 21% respectively). In 1995, 25% of the 109 PIT-tagged wild *O. nerka* released from the Redfish Lake Creek trap were interrogated between Lower Granite and McNary dams. Relatively high mainstem Snake River discharge occurred in 1991, 1993, and 1995. High flows have been associated with good survival to mainstem dam locations (Kiefer and Lockhart 1993; Raymond 1979). The cumulative, unique interrogation rate for 1995 wild outmigrants does not, however, reflect this trend. Operational inconsistencies (e.g., proportion of discharge spilled and gas saturation levels) from year to year may influence survival as well as flow rate.

The median travel time to Lower Granite dam was similar for outmigration years 1993, 1994, and 1995 (8.0 d, 12.0 d, and 10.7 d, respectively).

Wild outmigrants were more successful at reaching the dams in 1995 than sockeye salmon from any of the broodstock program release strategies employed in 1994 and 1995. Similar trends have been reported for natural steelhead and spring/summer chinook salmon (Terry Holubetz, Idaho Department of Fish and Game, Boise ID, personal communication; Kiefer and Lockhart, 1996).

Hatchery-Produced Outmigrants - Outmigration data collected at the Redfish Lake Creek trap in 1995 represented our first opportunity to monitor lake emigration for the supplementation groups released to Redfish Lake in 1994, the first year of broodstock program juvenile releases. From a release of 14,119 pre-smolt sockeye salmon, we estimated that approximately 823 fish (5.8%) emigrated from Redfish Lake between April 19 and June 15, 1995. Based on the absence of trap captures near the end of our trapping period and the absence of dam detections following the cessation of trapping, we feel no portion of the outmigration was missed. From PIT tag interrogations at the Redfish Lake Creek trap, we estimated that 93% and 7% of the 1995 lake outmigrants originated from the August 3, 1994 net pen and November 23, 1994 direct lake release strategies, respectively. If outmigrant detections for these two strategies had reflected the true proportion of PIT-tagged fish introduced to the lake in 1994, approximately 69% and 31% of outmigrant PIT tag detections would have been produced by net pen and direct lake release groups, respectively. We do not have sufficient information to speculate why net pen releases were detected significantly better than direct fall releases. The November fish consisted of only one lineage (BY91xBY91). This lineage was represented in the net pen strategy but comprised a small percentage of the total number of fish released (1.4%). The primary difference between these two supplementation groups was that fish from the November direct release group were produced in brood year 1993.5 (atypically late in the spawning year). To what extent this affected outmigration success is unclear.

Approximately 19% of the sockeye salmon introduced to the lake in 1994 were implanted with PIT tags. During 1995 outmigrant monitoring efforts at the Redfish Lake Creek trap, only 13% of the fish interrogated possessed PIT tags. Maynard et al. (1996) concluded that PIT tagging may have been responsible for the relatively low post-release survival observed between tagged and un-tagged groups of steelhead. Kiefer and Lockhart (1996), however, reported observing no significant difference in the rate of recapture for PIT-tagged and non-PIT-tagged wild/natural spring/summer chinook salmon in a side channel of the upper Salmon River. Within the captive broodstock program at the Eagle FH, we typically see high survival of PIT-tagged fish. In most cases, PIT-tagged broodstock production fish are maintained on station for several years. Mortalities do occur but are generally associated with other causes. At this time, we do not have enough information to speculate why we are seeing different interrogation rates for tagged and non-tagged fish.

The significant difference in outmigration success detected at the Redfish Lake Creek trap for the two release strategy groups planted in Redfish Lake in 1994 was not observed at the dams. Hatchery-produced progeny from the August 3, 1994 net pen release had been detected at the Redfish Lake Creek trap in significantly greater numbers than progeny from the November 23, 1994 direct lake release. We observed no significant difference between arrival time distributions for sockeye salmon from these two release strategies indicating that river conditions and dam operational conditions experienced by both release groups during outmigration were similar. These data indicated that from the point of release in 1994 to detection in 1995, progeny from both fall direct-lake and net pen pre-smolt release groups performed equally well with respect to numbers of fish past the dams. Any effect from the difference in brood years described above was not detected at the dams. Fall pre-smolt release strategies have been employed extensively in Alaska. Several authors have reported relatively high rates of outmigration success for fish released over this particular strategy (Carpenter 1991; Kelley 1993; Zadina and Haddix 1993). The use of freshwater net pen rearing with the subsequent release of fall pre-smolts is less common. Since 1989, however, the Washington Department of Fish and Wildlife has been involved with the enhancement of Lake Wenatchee sockeye salmon incorporating the use of net pens to rear hatchery-produced fry to the pre-smolt stage for fall release to the lake. First year adult returns of 1.3% were better than expected (Thomas 1993). Data from the Wenatchee system may be particularly relevant to our program as both stocks negotiate several dams on the Columbia River and travel considerable distance as smolts and adults.

With the exception of the wild outmigrants, hatchery-produced progeny from the April 21, 1995 smolt release (produced in brood year 1993.5) to Redfish Lake Creek were detected at a significantly higher rate than any of the other release options employed in 1994 and 1995. Several issues may confound these results, however. Mean fish lengths and weights were considerable greater for individuals from this group compared to individuals from the other release strategy groups. In addition, fish from this release group were one year older than fish from the different lake release options. No over-winter lake residency time was required for this group as well. While outmigration success past mainstem Snake and Columbia river dams was demonstrated to be relatively high for this release strategy, questions related to imprinting, the effect of absence of natural selection processes and potential benefits associated with lake residency, and the ability to return as adults remain unanswered. Despite our concerns, the practice of releasing sockeye salmon smolts has been used successfully in Alaska for many years (Amend et al. 1990). In most cases, fish are hatchery or net pen-reared and released within a relatively short distance from the ocean. Relatively high fry-to-smolt survival rates have been realized and smolt-to-adult return rates in excess of 15% are typical (Burke 1991).

Of all of the hatchery-produced outmigrant groups, progeny from the June 29, 1995 direct release to Redfish Lake strategy produced a cumulative, unique interrogation rate (although significantly different) most similar to that of the April 21, 1995 direct to Redfish Lake Creek smolt release group. A significant portion of the outmigrants from this release strategy selected to emigrate from Redfish Lake almost immediately after their introduction (median travel time of 8.5 d to Lower Granite Dam). Outmigrants from this particular strategy were released to the lake as age 0+ pre-smolts and, like net pen and direct lake fall pre-smolt releases, were expected to reside a minimum of one winter in Redfish Lake. As no estimate of outmigration for this release group was generated at the Redfish Lake Creek trap (trap disassembled prior to outmigration), it remains possible that a significant portion of these individuals selected to over-winter and outmigrate in 1996. Expanding the number of cumulative, unique interrogations between Lower Granite and McNary dams (104), it is reasonable to assume that over 400 PIT-tagged fish from this release strategy outmigrated in 1995 (0.25 average rate of detection used). Expanding this number based on the proportion of PIT-tagged to non-PIT-tagged fish yields a conservative outmigration estimate of over 4,000 fish.

Sockeye salmon smolts outmigrate as underyearlings (age 0+), yearlings (age 1+), age 2+ fish, and occasionally as age 3+ fish. The underlying factors that determine when fish outmigrate are fish size and time of year (Amend et al. 1990). Age of the fish appears to have little influence on survival except as a function of size. The production of age 0+ sockeye salmon smolts has been practiced in coastal Alaska systems since 1985 (Halloran 1988). Taylor and Heard (1993) reported smolt-to-adult survival rates of 3.3% to 11.3% for seawater reared sockeye salmon released as age 0+ smolts and counted as adult returns at the Auke Creek Hatchery. These results are relatively poor compared to smolt-to-adult survival rates typically achieved in coastal Alaska systems yet somewhat equivocal as they do not reflect adults lost to the commercial harvest. Halloran and Tollfeldt (1993) reported very poor survival of age 0+ smolts from the Beaver Falls Sockeye Facility in George Inlet near Ketchikan. Until adults return from age 0+ Redfish Lake outmigrants, it remains to be seen whether this will be considered an effective release option.

Upper Salmon River

Upper Salmon River estimated *O. nerka* outmigration has ranged from 8,000 fish in 1990 to 0 fish in 1993 and 1995 (Kline and Younk 1995). Alturas Lake is generally considered to be the source of this outmigration. Mitochondrial DNA and protein-gel electrophoretic data collected from Alturas Lake *O. nerka* trawl captures and from outmigrants captured at the Sawtooth FH trap generally support this assumption (Brannon et al. 1994; SBSTOC - January 1992).

Since 1992, midwater trawl surveys have documented very low young-of-the-year numbers in Alturas lake (Kline and Younk 1995). It stands to reason that very few outmigrants would be generated from such small year-classes. This trend of low outmigration numbers is expected to continue through the 1996 outmigration year as low numbers of age 0+ *O. nerka* were again detected in the September 1995 Alturas Lake trawl.

Lower Snake and Columbia river PIT tag interrogation rates for *O. nerka* outmigrants PIT-tagged and released at the Sawtooth FH trap are considerably lower than interrogation rates generated for Redfish Lake outmigrants. The cumulative, unique interrogation rate for *O. nerka* released from the Sawtooth FH trap in 1992 was 50% lower than the rate of detection produced by Redfish Lake outmigrants for that same year (Kline 1994). This trend has been repeated each year since the inception of the Sawtooth Valley Project.

Volitional Spawning Investigations

At the termination of 1994 telemetry efforts, 11 of 37 transmitters (29.7%) were still active (e.g., adult broodstock sockeye salmon fitted with ultrasonic transmitters recorded at new locations on successive tracking dates). Kline (1994) reported similar findings (33.3% active, eight of 24 transmitters) at the termination of the 1993 tracking investigation. In 1994, Kline and Younk (1995) reported that three of these fish (37.5%) had successfully over-wintered. Two of the survivors remained active for the duration of the 1994 tracking effort while the third fish was reported stationary (assumed dead) several weeks into the 1994 tracking investigation. No observations of site selection, site fidelity, or spawning-related behavior were noted for any of these fish. In 1995, none of the 11 broodstock adults, active at the termination of 1994 tracking efforts, were recorded moving (no over-winter survival assumed).

To date, 89 adult broodstock sockeye salmon have been released to spawn volitionally in Redfish Lake. Several observations of site selection and fidelity have been made but only one observation of spawning-related behavior has been recorded (Kline 1994).

The apparent lack of success of the Redfish Lake adult release strategy raises several concerns related to: 1) homing and site selection abilities of release groups; 2) pairing ability; and 3) maturation and gonadal development. Adult sockeye salmon releases have originated from two primary broodstock sources: 1) Redfish Lake outmigrants from 1991; and 2) first generation progeny of the three male and one female sockeye salmon that returned to Redfish Lake Creek in 1991. In both cases, the majority of the cohorts from these two lineages remained on station at the Eagle FH as broodstock. The selection of individual fish for release to Redfish Lake has been based primarily on observations of signs of maturation. The release of telemetry groups in August and early September, however, required making these selections prior to the time when obvious signs of maturation were evident.

Several inconsistencies related to maturation timing, percent egg eye-up, and gonadal development occurred among the cohorts of the adult release groups that remained on station at Eagle FH. Many of these characteristics surfaced during spawning activities conducted in 1993 and 1994, the same years that adult broodstock fish were released to Redfish Lake to spawn volitionally. In brood year 1993, adult maturation extended over an abnormally long period of time (e.g., brood year 93.5). In both brood years, fertilization rates were variable and generally averaged less than 40%. Higher than desirable rates of incomplete gonadal development and atresic and/or reabsorbed eggs have also occurred. To what extent this has affected the success of adult release fish is largely unknown.

Predator Investigations

Piscivory on juvenile sockeye salmon supplemented to Stanley Basin lakes is to be expected. The four nursery lakes of the Stanley Basin each support populations of predators including northern squawfish and bull trout (Redfish and Alturas lakes), over-wintered hatchery rainbow trout (Pettit Lake), and lake trout (Stanley Lake). Alturas and Stanley lakes do receive hatchery rainbow trout but to date, over-winter survival has not been documented. Past predator investigations have relied primarily on gill netting and trap netting to identify relative species abundance, catch rate, and diet (Liter and Lukens 1992; Kline 1994; Kline and Younk 1995; Teuscher and Taki 1995). In Basin lakes where ESA-listed sockeye salmon are present (Redfish and Pettit lakes) predator investigations are also subject to the provisions of the ESA and must comply with permit requirements set forth by NMFS (e.g., restrictions on the use of gill nets).

While past surveys have contributed to our understanding of the predator communities in Basin lakes, they have not satisfied our desire to understand more about predator population stability and abundance. For some species (e.g., northern squawfish), this task is very difficult. For others (e.g., over-wintered hatchery rainbow trout and lake trout), population estimates are presently being developed (Teuscher and Taki 1996). Bull trout, however, remain one of the least understood predators of the Stanley Basin lakes. From recent gill net surveys we know they comprise approximately 5.0% of the total catch (Liter and Lukens 1992; Kline 1994). Diet information from gill net surveys has also confirmed that they prey on sockeye salmon. We do not understand, however, whether populations are static, decreasing, or growing. The need to collect this information is particularly relevant today as Idaho fishing regulations for bull trout in Stanley Basin waters were changed from a six-fish bag limit to "no harvest" on January 1, 1994. Without understanding more about the status of Basin bull trout populations, it will be difficult to thoroughly interpret variables such as over-winter survival and outmigration success of juvenile sockeye salmon released to nursery lakes from the captive broodstock program.

Adult adfluvial bull trout spawn in tributary streams of Alturas and Redfish lakes. This stage of their life cycle provides one of the best opportunities we have to document various escapement and production variables. Adult spawner and redd surveys have been successfully used to follow the freshwater production stage of Idaho stocks of chinook salmon and steelhead (Kiefer and Lockhart 1996; Nemeth et al. 1996). This information has been used to document trends in adult escapement and to estimate annual production and juvenile recruitment. Investigations of this kind have also been used to document similar trends in adfluvial bull trout populations. Using adult spawner and redd counts, Stelfox and Egan (1995) documented a five-fold increase in bull trout spawner and redd numbers in the Smith-Dorrien Creek/Lower Kananaskis Lake system of British Columbia just two years after the implementation of no harvest fishing regulations for bull trout. In Oregon, the implementation of catch-and-release regulations for all wild trout and charr in the Metolius River in 1982 had a similar effect on the bull trout population (Ratliff 1992). Redd counts in four tributaries of Lake Billy Chinook steadily increased from 27 in 1986 to 142 in 1989.

Our efforts to establish trend sections on Alturas and Redfish Lake tributaries were not completed in 1995. First year surveys identified areas that might support bull trout spawning but were not investigated. In 1996, final trend sections will be established. We recommend that bull trout spawner and redd surveys be conducted on an annual basis to establish similar trend data to enable a better interpretation of the results of hatchery-produced juvenile sockeye salmon supplementation to Stanley Basin waters.

Parental Lineage Investigations

During the development of ova, vitellogenesis in anadromous fish begins while the female parent is in the ocean. Conversely, this process occurs entirely in freshwater for non-anadromous, non-marine species. Strontium can partially substitute for Ca in the formation of vitellogenin, the precursor to yolk in developing ova. As development continues, Sr can partially substitute for Ca in the aragonite matrix of the first calcified structures to form: the otolith primordia. As fish grow, Sr continues to interchange with Ca in the depositional process of otoliths (Kalish 1989,1990; Radtke 1989). Kalish (1990) and Rieman et al. (1993) concluded that Sr/Ca ratios in otoliths and ova reflect the relative amounts of Sr and Ca in the environment. Typically, Sr/Ca ratios are higher for marine waters than for fresh waters.

Otolith microchemistry has been used to discriminate individual fish from female parents of known anadromous and freshwater origin. Kalish (1990) reported that differences between Sr/Ca ratios in otolith primordia of sea-farmed and freshwater juvenile rainbow trout were great enough to identify individual life history (with respect to habitat location) during egg development. Mean nuclear Sr/Ca ratios reported by Kalish (1990) were between 0.0022 and 0.0052 for the progeny of sea-farmed rainbow trout. Rieman et al. (1993) reported mean nuclear Sr/Ca ratios between 0.0011 and 0.0020 for sockeye salmon progeny with known lineage to female anadromous adults. All but one of the otoliths analyzed by Rieman et al. (1993) yielded Sr/Ca ratios greater than 0.0014. Secor et al. (1994) used otolith microchemistry to describe the environmental life history of individual striped bass *Morone saxatilis* across a salinity gradient. They reported that mean, nuclear Sr/Ca between 0.0020 and 0.0030 were indicative of estuarine salinities and ratios greater than 0.0035 were indicative of marine salinities.

Rieman et al. (1993) observed mean nuclear Sr/Ca ratios greater than 0.0014 in otoliths of the five anadromous adult sockeye salmon that returned to Redfish Lake in 1991 and 1992. They concluded that all five adults were direct descendants of female anadromous parents that initiated egg development in saltwater. The mean, nuclear Sr/Ca ratio from the one anadromous female sockeye salmon that returned to Redfish Lake in 1994 also reflected direct lineage to an anadromous female parent (Kline and Younk 1995). Kline (1994) reported, however, that two of the eight anadromous adult sockeye salmon that returned to Redfish Lake in 1993 exhibited microchemistry results that suggested direct lineage to freshwater female parents (<0.0008). Kline (1994) speculated these data could link anadromous adults to the freshwater residual sockeye salmon component of Redfish Lake. One of the eight anadromous adults analyzed by Kline (1994) exhibited mean, nuclear Sr/Ca results indicative of uncertain lineage (0.0008-0.0014).

Rieman et al. (1993) and Kline (1994) observed a range in Sr/Ca data for 1991 Redfish Lake outmigrants (unknown origin) suggesting direct lineage to both freshwater (Sr/Ca <0.0008) and saltwater (Sr/Ca >0.0014) female parents. Approximately one-third of their results, however, were regarded as equivocal (Sr/Ca 0.0008-0.0014) based on microchemistry data from progeny of known saltwater and freshwater origin. In 1995, we analyzed only otolith nuclei from progeny with known lineage to anadromous female sockeye salmon or Fishhook Creek kokanee. Increasing the sample size of otolith microchemistry data for progeny associated with known life history will help refine our interpretation of the origin of Stanley Basin *O. nerka* with uncertain life history.

In 1995, no further investigations of otolith Sr/Ca ratios were conducted for progeny of the single female sockeye salmon that returned to Redfish Lake in 1991. Past investigations by Rieman et al. (1993) Kline (1994) and Kline and Younk (1995) produced results consistent with known saltwater lineage. In all cases (71 samples), mean Sr/Ca ratios observed in otolith nuclei were greater than 0.0014. These data indicate that wavelength dispersive electron microprobe analyses of like-origin otoliths can produce repeated measures of consistent results over time.

We analyzed twenty-one otolith samples from progeny of the two anadromous female adult sockeye salmon that returned to Redfish Lake in 1993. Mean, nuclear Sr/Ca microchemistry results were less consistent than results from the 1991 female. One of the 21 samples exhibited Sr/Ca results indicative of uncertain life history (0.0008-0.0014). Kline and Younk (1995) reported similar findings for progeny produced by these same two female adults. Four of the 11 samples they analyzed produced mean, nuclear Sr/Ca results that fell below 0.0014 indicating some deviation from the data set established by Rieman et al. (1993) and supported by Kline (1994). A number of biological factors may influence the substitution of Sr for Ca in developing otoliths (Kalish 1989). During the transition from saltwater to freshwater, anadromous salmonids are affected by these and other factors that could influence this process. The anadromous female parents of the progeny investigated in this study all moved into freshwater at some point during egg development. Strontium/calcium ratios in otoliths have been shown to reflect the salinity of the water encountered by the adult female during egg development (Kalish 1990; Secor et al. 1994). Mean Sr/Ca ratios observed in otolith nuclei of brood year 1993 anadromous progeny reflect the possibility that ova development and the uptake of Sr was not complete at the time of adult entry to freshwater (other biological factors aside). Kalish (1990) suggested that the development of ova in anadromous salmonids is virtually complete before fish enter fresh water. Our data suggest the possibility that this is not necessarily true, or, that other biological factors are operating to over shadow the effects of changing salinity on the uptake of Sr in developing ova. Unfortunately, individual otoliths could not be traced back to one of the two 1993 female adult sockeye salmon. The possibility remains that one female produced the five ova that developed nuclear Sr/Ca values between 0.0008 and 0.0014. The majority of nuclear Sr/Ca results produced by both of the 1993 adult female sockeye salmon did, however, exceed 0.0014.

In 1995, we analyzed 43 otolith samples from progeny of the one adult sockeye salmon that returned to Redfish Lake in 1994 to further increase our sample size of known-lineage data. In all cases, mean, nuclear Sr/Ca ratios exceeded 0.0014. To date, 146 samples from progeny of the four female adult sockeye salmon that have returned to Redfish Lake since 1991 have been analyzed. In all but five examples, the results have been consistent with our expectations of direct lineage to female anadromous parents (Sr/Ca >0.0014). The five equivocal values are all associated with the two females that returned in 1993.

The 21 otolith samples analyzed in 1995 from Fishhook Creek kokanee produced mean, nuclear Sr/Ca results consistently less than 0.0008. These data agree with the original data set established for this stock by Rieman et al. (1993).

Redfish Lake Kokanee Fishery Investigation

The Redfish Lake kokanee fishery was closed to harvest in 1993. That same year, IDFG's permit to stock hatchery rainbow trout in Redfish Lake was not reissued by NMFS. This action was brought about by the 1993 listing of the residual form of Redfish Lake sockeye salmon as endangered under the ESA. NMFS concluded that a harvest-oriented fishery could jeopardize the residual component of the Redfish Lake sockeye salmon population. It was further felt that the introduction of hatchery rainbow trout would pose a predation risk to the residual component of the population.

One of the strategies adopted by the SBSTOC to enhance the survival of hatchery-produced juvenile sockeye salmon in Redfish Lake is the partial reduction of resident kokanee biomass. In 1995, re-opening the kokanee fishery was introduced as one method of partially accomplishing this objective (SBSTOC - May 1995). On July 15, the Redfish Lake kokanee fishery was re-opened to harvest (six-fish bag limit) through July 31. The season was closed to harvest on August 1 to protect residual sockeye salmon that remain in the lake after their kokanee counterpart escape to Fishhook Creek to spawn (note: residual sockeye salmon remain in Redfish Lake and beach spawn in October and November).

The estimated angler effort for the 17-d fishery in 1995 (2,554 h) generally reflects effort targeted specifically at kokanee. Most anglers interviewed were aware of the absence of hatchery rainbow trout and only a few were specifically targeting bull trout. The two most recent creel investigations of Redfish Lake reported that anglers fished an estimated 15,449 h and 12,507 h during the 1986 and 1987 full season fisheries, respectively (Reingold and Davis 1986; Davis and Reingold 1988). Although not reported, the majority of this effort was most likely devoted to the pursuit of hatchery rainbow trout. July effort for the 1986 and 1987 seasons was estimated at 5,177 h and 4,289 h, respectively. Considering that rainbow trout were not targeted during this year's fishery, estimated angler effort for 1995 is, by comparison, respectable and represents a strong renewed interest in the Redfish Lake kokanee fishery.

Anglers caught an estimated 465, 480, and 440 kokanee during the month of July for the 1986, 1987, and 1995 Redfish Lake fisheries, respectively. Catch rates during July for these three years averaged 0.09, 0.11, and 0.15 kokanee/h, respectively.

RECOMMENDATIONS

1. Continue the utilization of several strategies for the release of juvenile broodstock program-produced sockeye salmon. Avoid placing emphasis on early results which indicate releasing age 1+ smolts below the weir on Redfish Lake Creek yields the best outmigration success.

2. Maintain the release of adult broodstock sockeye salmon as a viable strategy. Postpone releasing fish until sex and stage of maturation can be confirmed. Continue to pursue techniques within the hatchery to improve the performance of adult outplants.

3. Broodstock program lineage groups should be represented over all release strategies to facilitate the uniform evaluation of outmigration success.

4. Conduct bull trout spawner and redd count surveys annually. The effects of fish predation on juvenile hatchery-produced outplants is not well understood.

5. Monitor the Redfish Lake kokanee fishery annually. Continue cooperative efforts with the SBT to control kokanee biomass in Fishhook Creek. Initiate Pettit Lake kokanee fishery monitoring in 1996.

ACKNOWLEDGMENTS

Special thanks:

To David Teuscher and Doug Taki of the SBT for their many contributions to IDFG's efforts associated with the Sawtooth Valley Project. To Brent Snider and the staff of IDFG's Sawtooth Fish Hatchery for providing daily field support and a comfortable base for field operations. To Keith Johnson, Steve Wingert and Jay Pravececk of the Eagle Fish Hatchery for their continued interest in and support of "the other part" of the project.

To Russ Kiefer, Jerry Lockhart, Doug Nemeth, Paul Bunn, and Clint Rasmussen (IDFG) for providing the majority of the effort required to PIT tag outmigrating smolts at both weir sites. To Clark Shackelford for piloting the IDFG trawl boat and for assisting with the processing of hundreds of trawl samples.

To Bruce Rieman, Debbie Myers, and Lori Leatherbury (USDA Forest Service Intermountain Research Station, Boise, ID) for their assistance with otolith sample preparation. To Roger Nielsen (Oregon State University, Corvallis, OR) for his timely analysis of otolith samples.

To Melo Maiolie, Keith Johnson, Russ Kiefer, Jay Pravececk and Al Van Vooren for providing helpful comments on the draft report. To Kathie Fitzgerald and Sherri Moedl for word processing assistance.

Funding provided by the U.S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, through Project No. 91-72; Contract No. DE-BI79-91BP21065. Special thanks to Jeffrey Gislason for his continued support of the project and special talent for guiding the SBSTOC.

LITERATURE CITED

Amend, D.F., W. Halloran, and M. Tollfeldt. 1990. Hatchery rearing and release strategies for sockeye. 1990. Proceedings of the Sockeye Culture Workshop, Anchorage, Alaska. July 10 - 11, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Bjornn, T.C., D.R. Craddock, and D.R. Corley. 1968. Migration and survival of Redfish Lake, Idaho, sockeye salmon, Oncorhynchus nerka. Transactions of the American Fisheries Society, 97:360-373.

Brannon, E., A. Setter, T. Welsh, R. Danner, K. Collins, M. Casten, G. Thorgaard, K. Adams, and S. Cummings. 1994. Genetic analysis of Oncorhynchus nerka: Life history and genetic analysis of Redfish Lake Oncorhynchus nerka. Completion Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 90-93, Contract No. DE-BI79-90BP12885, Portland, OR.

Burke, J. 1991. Yearling smolt production, Main Bay sockeye smolt program. Proceedings of the Sockeye Culture Workshop, Sitka, Alaska. October 24 - 25, 1991. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Carpenter, G. 1991. Sockeye salmon fry and pre-smolt stocking at Pass and Esther Pass lakes in Prince William Sound. Proceedings of the Sockeye Culture Workshop, Sitka, Alaska. October 24 - 25, 1991. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Chapman, D.W., W.S. Platts, D. Park, and M. Hill. 1990. Status of Snake River sockeye salmon. Don Chapman Consultants, Inc., Boise, ID.

Cohen, J. 1988. Statistical power analysis for the behavioral sciences, 2nd ed. Lawrence Erlbaum Associates, Hillsdale, N.J.

Davis, J.A., and M. Reingold. 1988. Regional fisheries management investigations. Job No. 6 (SAL)-b^2. Salmon subregion lake and reservoir investigations, Stanley Basin lakes. Job Performance Report, Project F-71-R-12. Idaho Department of Fish and Game, Boise, ID.

Fleiss, J.L. 1981. Statistical methods for rates and proportions, 2nd ed. Wiley and Sons, New York, NY.

Foerster, R.E. 1968. The sockeye salmon, Oncorhynchus nerka. Fisheries Research Board of Canada. Bulletin 162.

Goodlad, J.C., T.W. Ghernes, and E.L. Brannon. 1974. Factors affecting sockeye salmon (Oncorhynchus nerka) growth in four lakes of the Fraser River system. Journal of the Fisheries Research Board of Canada 31:871-892.

Halloran, W. 1988. Southern southeast regional aquaculture association sockeye. Proceedings of the Sockeye Culture Workshop, Ketchikan, Alaska. July 12 - 13, 1988. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Halloran, W., and M. Tollfeldt. 1993. Evaluation of BY1989 age zero sockeye. Proceedings of the Sockeye Culture Workshop, Copper Landing, Alaska. November 2 - 3, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Hall-Griswold, J.A. 1990. Sockeye salmon of the Stanley Basin summary. Report to the Idaho Department of Fish and Game.

IDFG (Idaho Department of Fish and Game). 1992. Anadromous fish management plan 1992-1996. Idaho Department of Fish and Game, Boise, ID.

Kalish, J.M. 1989. Otolith microchemistry: validation of the effects of physiology, age and environment on otolith composition. Journal of Experimental Marine Biology and Ecology. 132: 151-178.

Kalish, J.M. 1990. Use of otolith microchemistry to distinguish the progeny of sympatric anadromous and non-anadromous salmonids. Fishery Bulletin, 88: 657-666.

Kelley, S. 1993. Crescent Lake sockeye salmon enhancement activities. Proceedings of the Sockeye Culture Workshop, Copper Landing, Alaska. November 2 - 3, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Kiefer, R.B., and K. Forster. 1991. Intensive evaluation and monitoring of chinook salmon and steelhead trout production, Crooked River and upper Salmon River sites. Idaho Department of Fish and Game. Annual Progress Report, 1989 to U.S. DOE, Bonneville Power Administration, Division of Wildlife. Contract No. DE-B179-84BP13381. Portland, OR.

Kiefer, R.B., and J.N. Lockhart. 1993. Idaho Habitat & Natural Production Monitoring: Part II. Idaho Department of Fish and Game. Annual Report, 1992 to U.S. DOE, Bonneville Power Administration, Division of Wildlife. Project No. 91-73, Contract No. DE-B179-91BP21182. Portland, OR.

Kiefer, R.B., and J.N. Lockhart. (1996). Intensive evaluation and monitoring of chinook salmon and steelhead trout production, Crooked River and upper Salmon River sites. Idaho Department of Fish and Game. Annual Progress Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-73, Contract No. DE-BI79-91BP21182. Portland, OR.

Kline, P.A. 1994. Research and recovery of Snake River sockeye salmon. Idaho Department of Fish and Game. Annual Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-72, Contract No. DE-BI79-91BP21065. Portland, OR.

Kline, P.A., and J. Younk. 1995. Research and recovery of Snake River sockeye salmon. Idaho Department of Fish and Game. Annual Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-72, Contract No. DE-BI79-91BP21065. Portland, OR.

Koenings, J.P., and R.D. Burkett. 1987. An aquatic Rubic's cube: Restoration of the Karluk Lake sockeye salmon (Oncorhynchus nerka). *In* H.D. Smith, L. Margolis, and C.C. Wood [ed.] sockeye salmon (Oncorhynchus nerka) population biology and future management. Can. Spec. Publ. Fish. Aquat. Sci. 96. p.419-434.

Koenings, J.P., and G.B. Kyle. 1994. Collapsed populations and delayed recovery of zooplankton in response to heavy juvenile sockeye salmon (Oncorhynchus nerka) foraging. Alaska Department of Fish and Game. Fisheries Rehabilitation, Enhancement, and Development Division.

Liter, M., and J.R. Lukens. 1992. Region 7 lake and reservoir investigations - Alturas, Redfish, and Williams Lakes. Idaho Department of Fish and Game, Job Performance Report, Project No. F-71-R-16, Job No. 7-b. Boise, ID.

Maynard, D.J., D.A. Frost, F.W. Waknitz, and E.F. Prentice. 1996. Vulnerability of marked age-0 steelhead to a visual predator. Transactions of the American Fisheries Society, 125:330-333.

McArthur, T. 1992. Statewide angler opinion and harvest surveys, creel census system. Idaho Department of Fish and Game, Job Performance Report, Project No. F-71-R-14, Subproject 1, Study 1. Boise, ID

McDonald, J., and J.M. Hume. 1984. Babine Lake sockeye salmon (Onchorhynchus nerka) enhancement program: testing some major assumptions. Canadian Journal of Fisheries and Aquatic Sciences 41:70-92.

Nemeth, D., K. Plaster, E. Brown, and P. Hassemer. 1996. Idaho Supplementation Studies. Idaho Department of Fish and Game. Annual Progress Report to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 89-098. Portland, OR.

Parkinson, E.A., B.E. Rieman, and L.G. Rudstam. 1994. Comparison of acoustic and trawl methods for estimating density and age composition of kokanee. Transactions of the American Fisheries Society 123:841-854.

Radtke, R.L. 1989. Strontium-calcium concentration ratios in fish otoliths as environmental indicators. Comparative Biochemistry and Physiology. 92A: 189-193.

Ratliff, D.E. 1992. Bull trout investigations in the Metolius River-Lake Billy Chinook system. *In* Howell, P.J. and D.V. Buchannan, ed. Proceedings of the Gearhart Mountain bull trout workshop. Oregon Chapter of the American Fisheries Society, Corvallis, OR.

Raymond, H.L. 1979. Effects of dams and impoundments on migrations of juvenile chinook salmon and steelhead from the Snake River, 1966 to 1975. Transactions of the American Fisheries Society 108:505-529.

Reingold, M., and J.A. Davis. 1987. Regional fisheries management investigations. Job No. 6 (SAL) b^2. Salmon subregion lake and reservoir investigations, Stanley Basin lakes. Job Performance Report, Project F-71-R-11. Idaho Department of Fish and Game, Boise, ID.

Ricker, W.E. 1937. The food and food supply of sockeye salmon (Oncorhynchus nerka Walbaum) in Cultus Lake, British Columbia. J. Biol. Bd. Can. 3:450-468.

Rieman, B.E. 1992. Kokanee salmon population dynamics - kokanee salmon monitoring guidelines. Idaho Department of Fish and Game, Project No. F-73-R-14, Subproject II, Study II. Boise, ID.

Rieman, B.E. and D.L. Meyers. 1990. Status and analysis of salmonid fisheries - kokanee population dynamics. Idaho Department of Fish and Game, Job Performance Report, Project No. F-73-R-12, Job No. 1. Boise, ID.

Rieman, B.E., and D.L. Meyers. 1991. Kokanee population dynamics, costs, benefits and risks of salmonid predators in kokanee waters. Idaho Department of Fish and Game, Job Completion Report, Project No. F-73-R-13, Job No. 1. Boise, ID.

Rieman, B.E., D.L. Myers, and R.L. Nielsen. 1993. The use of otolith microchemistry to discriminate Oncorhynchus nerka of resident and anadromous origin. Idaho Department of Fish and Game. Boise, ID.

SBSTOC (Stanley Basin Sockeye Technical Oversight Committee). 1992. Monthly meeting minutes. U.S. DOE, Bonneville Power Administration, Fish and Wildlife Division. Portland OR.

SBSTOC (Stanley Basin Sockeye Technical Oversight Committee). 1994. Monthly meeting minutes. U.S. DOE, Bonneville Power Administration, Fish and Wildlife Division. Portland OR.

SBSTOC (Stanley Basin Sockeye Technical Oversight Committee). 1995. Monthly meeting minutes. U.S. DOE, Bonneville Power Administration, Fish and Wildlife Division. Portland OR.

SBSTOC (Stanley Basin Sockeye Technical Oversight Committee). 1996. Monthly meeting minutes. U.S. DOE, Bonneville Power Administration, Fish and Wildlife Division. Portland OR.

Secor, D.H., E. D. Houde, A. Heneerson-Arzapalo, and P.M. Picoli. 1994. Tracking the migrations of estuarine and coastal fishes using otolith microchemistry. International Council for the Exploration of the Sea, 1993.

Sokal, R.R., and F.J. Rohlf. 1981. Biometry, 2nd ed. W.H. Freeman and Company, New York, NY.

Stelfox, J.D., and K.L. Egan. 1995. Bull trout investigations in the Smith-Dorrien Creek/lower Kananaskis Lake system. Alberta Environmental Protection, Fisheries Management Division, and Golder Associates Limited, Calgary, CAN.

Taylor, S.G. and W.R. Heard. 1993. Adult survivals of three broods of age-0 (underyearling) sockeye salmon smolts reared in fresh and sea water at Auke Creek, Alaska. Proceedings of the Sockeye Culture Workshop, Copper Landing, Alaska. November 2 - 3, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Teuscher, D., and D. Taki. 1994. Snake River sockeye salmon habitat and limnological research. Annual Report 1993 to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-71, Contract No. DE-BI79-91BP22548. Portland, OR.

Teuscher, D., and D. Taki. 1995. Snake River sockeye salmon habitat and limnological research. Annual Report 1994 to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-71, Contract No. DE-BI79-91BP22548. Portland, OR.

Teuscher, D., and D. Taki. 1996. Snake River sockeye salmon habitat and limnological research. Annual Report 1995 to U.S. DOE, Bonneville Power Administration, Division of Fish and Wildlife. Project No. 91-71, Contract No. DE-BI79-91BP22548. Portland, OR.

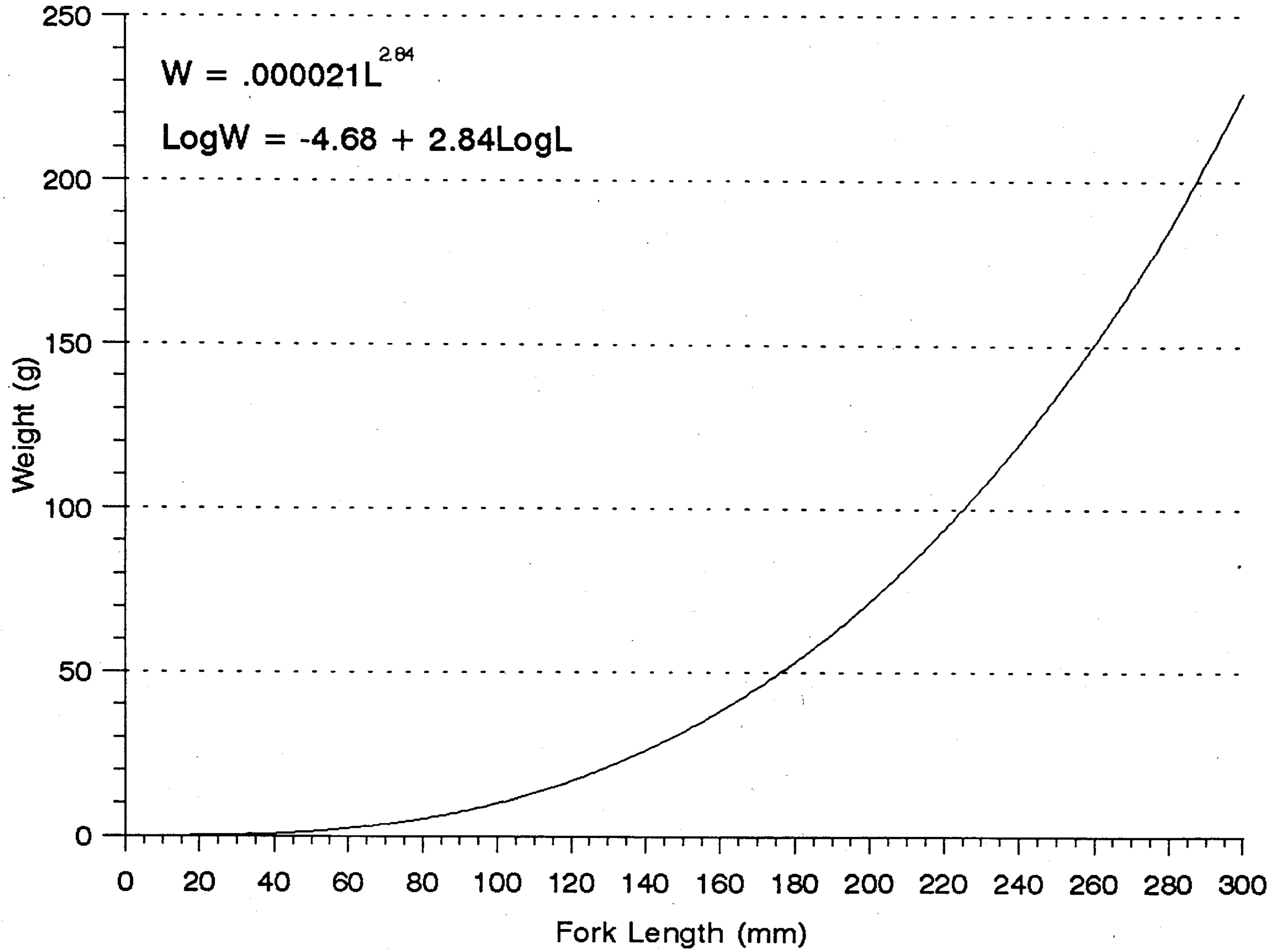
Thomas, J. 1993. Lake Wenatchee sockeye. Proceedings of the Sockeye Culture Workshop, Copper Landing, Alaska. November 2 - 3, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Toole, C.L., and R.L. Nielsen. 1992. Effects of microprobe precision on hypotheses related to otolith Sr:Ca ratios. Fishery Bulletin, 41: 239-255.

Zadina, T., and M. Haddix. 1993. Consequences of and solutions to early fry release timing in Virginia Lake. Proceedings of the Sockeye Culture Workshop, Copper Landing, Alaska. November 2 - 3, 1993. Compiled by the Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement, and Development.

Zar, J.H. 1974. Biostatistical Analysis. 1974. Prentice-Hall, Inc., Englewood Cliffs, NJ.

APPENDICES



Appendix A. Weight-length relationship for hatchery-produced sockeye salmon.

Appendix B. Length, weight, lineage, and sex information for 1994 ultrasonic-tagged adult captive broodstock sockeye salmon outplants to Redfish Lake. OM91 = 1991 outmigrants, OM92 = 1992 outmigrants, BY91 = progeny of 1991 anadromous adults.

Codes[a]	Fork Length (mm)	Weight (g)	Lineage	Sex
97	555	2898	OM91	FM
13-3	610	3480	OM91	FM
266	570	3070	OM91	FM
366	590	3074	OM91	M
455	570	2920	OM91	M
464	575	2910	OM91	FM
473	555	2580	OM91	FM
2228	595	3346	OM91	FM
2237	610	2000	OM91	M
2345	600	2732	OM91	M
2354	560	2862	OM91	M
2363	670	4310	OM91	M
2435	555	2372	OM91	M
2543	540	2410	OM91	FM
2633	528	2778	OM91	M
14-2	490	1516	OM92	FM
356	538	2118	OM92	FM
88	520	2200	BY91	FM
10-6	540	2250	BY91	FM
11-5	520	2190	BY91	FM
12-4	520	2215	BY91	FM
239	540	2440	BY91	M
248	540	2278	BY91	FM
285	480	1520	BY91	FM
293	510	1980	BY91	FM
338	595	3220	BY91	FM
347	515	2158	BY91	FM
374	580	3200	BY91	M
365	535	2092	BY91	FM
446	537	2704	BY91	FM
554	590	2890	BY91	M
555	580	2860	BY91	M
2273	535	2286	BY91	FM
2426	590	3090	BY91	M
3335	454	2642	BY91	M
3344	545	2390	BY91	FM
3434	530	2250	BY91	FM

[a] Frequencies are 70 to 76 KHz ± 2 KHz

Appendix C. Age, weight, and fork length of *O. nerka* captured in 1995 midwater trawls of four Stanley Basin lakes. RFL=Redfish Lake, ALT=Alturas Lake, PET=Pettit Lake, STA=Stanley Lake, na=not aged.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
RFL 6/27/95	01	na	27	0.1
RFL 6/27/95	02	na	29	0.2
RFL 6/27/95	03	na	33	0.3
RFL 6/27/95	04	na	78	3.9
RFL 6/27/95	05	na	80	4.7
RFL 6/27/95	06	na	83	4.9
RFL 6/27/95	07	na	86	5.4
RFL 9/26/95	01	0+	46	0.9
RFL 9/26/95	02	0+	49	1.0
RFL 9/26/95	03	0+	51	1.2
RFL 9/26/95	04	0+	51	1.2
RFL 9/26/95	05	0+	55	1.5
RFL 9/26/95	06	0+	56	1.6
RFL 9/26/95	07	0+	57	1.5
RFL 9/26/95	08	0+	58	1.7
RFL 9/26/95	09	0+	59	1.8
RFL 9/26/95	10	0+	60	1.7
RFL 9/26/95	11	0+	60	2.0
RFL 9/26/95	12	0+	62	2.2
RFL 9/26/95	13	0+	65	2.3
RFL 9/26/95	14	0+	65	2.6
RFL 9/26/95	15	0+	65	2.3
RFL 9/26/95	16	0+	66	2.6
RFL 9/26/95	17	0+	66	2.7
RFL 9/26/95	18	0+	67	2.4
RFL 9/26/95	19	0+	70	3.3
RFL 9/26/95	20	0+	70	3.2
RFL 9/26/95	21	0+	72	3.4
RFL 9/26/95	22	0+	73	3.6
RFL 9/26/95	23	0+	73	3.4
RFL 9/26/95	24	0+	74	4.1
RFL 9/26/95	25	0+	76	4.0
RFL 9/26/95	26	0+	79	4.8
RFL 9/26/95	27	1+	87	6.2
RFL 9/26/95	28	1+	89	6.2
RFL 9/26/95	29	1+	96	8.4
RFL 9/26/95	30	1+	97	8.6
RFL 9/26/95	31	1+	100	9.2
RFL 9/26/95	32	1+	101	9.0
RFL 9/26/95	33	1+	102	10.2
RFL 9/26/95	34	1+	104	10.5
RFL 9/26/95	35	1+	110	10.9
RFL 9/26/95	36[a]	1+	111	15.0

Appendix C. Continued.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
RFL 9/26/95	37	2+	153	36.8
RFL 9/26/95	38	2+	155	42.6
RFL 9/26/95	39	2+	158	47.1
RFL 9/26/95	40	2+	164	51.1
RFL 9/26/95	41	2+	168	58.7
RFL 9/26/95	42	2+	172	56.3
RFL 9/26/95	43	2+	175	55.6
RFL 9/26/95	44	2+	177	52.8
RFL 9/26/95	45	2+	178	62.7
RFL 9/26/95	46	2+	179	64.1
RFL 9/26/95	47	2+	183	69.3
RFL 9/26/95	48	2+	185	74.0
RFL 9/26/95	49	2+	187	74.0
RFL 9/26/95	50	2+	189	75.1
RFL 9/26/95	51	2+	190	78.9
RFL 9/26/95	52	2+	191	78.5
RFL 9/26/95	53	2+	192	84.0
RFL 9/26/95	54	2+	193	87.3
RFL 9/26/95	55	2+	194	88.4
RFL 9/26/95	56	2+	194	82.3
RFL 9/26/95	57	2+	194	72.3
RFL 9/26/95	58	2+	194	85.5
RFL 9/26/95	59	2+	194	82.7
RFL 9/26/95	60	2+	195	79.8
RFL 9/26/95	61	2+	195	88.3
RFL 9/26/95	62	2+	195	85.8
RFL 9/26/95	63	2+	195	82.1
RFL 9/26/95	64	2+	196	88.6
RFL 9/26/95	65	2+	196	91.5
RFL 9/26/95	66	2+	197	87.9
RFL 9/26/95	67	2+	198	84.9
RFL 9/26/95	68	2+	199	91.9
RFL 9/26/95	69	2+	200	87.9
RFL 9/26/95	70	2+	200	90.9
RFL 9/26/95	71	2+	200	87.2
RFL 9/26/95	72	2+	200	96.5
RFL 9/26/95	73	2+	201	91.6
RFL 9/26/95	74	2+	203	97.0
RFL 9/26/95	75	2+	203	102.5
RFL 9/26/95	76	2+	207	97.9
RFL 9/26/95	77	3+	204	100.6
RFL 10/24/95	01	na	59	1.7
RFL 10/24/95	02	na	59	1.8
RFL 10/24/95	03	na	64	2.2
RFL 10/24/95	04	na	66	2.2

Appendix C. Continued.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
RFL 10/24/95	05	na	68	3.0
RFL 10/24/95	06	na	75	3.6
RFL 10/24/95	07	na	80	4.9
RFL 10/24/95	08	na	86	6.1
RFL 10/24/95	09[a]	na	87	6.8
RFL 10/24/95	10	na	90	7.0
RFL 10/24/95	11[a]	na	97	9.1
RFL 10/24/95	12[a]	na	97	9.2
RFL 10/24/95	13	na	98	11.9
RFL 10/24/95	14[a]	na	102	16.1
RFL 10/24/95	15[a]	na	102	10.7
RFL 10/24/95	16[a]	na	109	12.9
RFL 10/24/95	17	na	110	11.6
RFL 10/24/95	18	na	112	11.9
RFL 10/24/95	19	na	176	63.8
RFL 10/24/95	20	na	178	67.0
RFL 10/24/95	21	na	180	65.8
RFL 10/24/95	22	na	180	70.6
ALT 9/25/95	01	0+	68	2.7
ALT 9/25/95	02	1+	106	11.8
ALT 9/25/95	03	1+	110	12.4
ALT 9/25/95	04	1+	111	13.2
ALT 9/25/95	05	1+	113	14.1
ALT 9/25/95	06	2+	125	18.3
ALT 9/25/95	07	2+	130	20.1
ALT 9/25/95	08	2+	137	23.2
ALT 9/25/95	09	2+	138	22.8
ALT 9/25/95	10	2+	140	23.2
ALT 9/25/95	11	2+	142	23.9
ALT 9/25/95	12	3+	135	23.0
ALT 9/25/95	13	3+	135	25.5
ALT 9/25/95	14	3+	138	22.8
ALT 9/25/95	15	3+	138	23.7
ALT 9/25/95	16	3+	139	22.7
ALT 9/25/95	17	3+	140	22.0
ALT 9/25/95	18	3+	140	24.9
ALT 9/25/95	19	3+	140	25.1
ALT 9/25/95	20	3+	141	26.6
ALT 9/25/95	21	3+	141	25.5
ALT 9/25/95	22	3+	141	23.8
ALT 9/25/95	23	3+	141	26.0
ALT 9/25/95	24	3+	142	25.1
ALT 9/25/95	25	3+	142	23.6
ALT 9/25/95	26	3+	143	25.2
ALT 9/25/95	27	3+	143	25.0

Appendix C. Continued.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
ALT 9/25/95	28	3+	143	25.0
ALT 9/25/95	29	3+	143	23.7
ALT 9/25/95	30	3+	144	24.8
ALT 9/25/95	31	3+	145	28.8
ALT 9/25/95	32	3+	145	24.0
ALT 9/25/95	33	3+	145	24.9
ALT 9/25/95	34	3+	145	25.3
ALT 9/25/95	35	3+	145	26.7
ALT 9/25/95	36	3+	146	26.2
ALT 9/25/95	37	3+	147	25.7
ALT 9/25/95	38	3+	147	27.7
ALT 9/25/95	39	3+	148	22.7
ALT 9/25/95	40	3+	148	29.1
ALT 9/25/95	41	3+	148	28.2
ALT 9/25/95	42	3+	149	27.6
ALT 9/25/95	43	3+	150	33.3
ALT 9/25/95	44	3+	150	30.4
ALT 9/25/95	45	3+	150	31.1
ALT 9/25/95	46	3+	154	32.2
ALT 9/25/95	47	3+	154	31.6
ALT 9/25/95	48	4+	143	24.5
ALT 9/25/95	49	4+	144	26.5
ALT 9/25/95	50	4+	145	24.1
ALT 9/25/95	51	4+	145	26.1
ALT 9/25/95	52	4+	146	25.3
ALT 9/25/95	53	4+	147	26.7
ALT 9/25/95	54	4+	148	25.6
ALT 9/25/95	55	4+	150	25.9
ALT 9/25/95	56	4+	155	32.6
PET 9/24/95	01	1+	91	7.6
PET 9/24/95	02	1+	93	7.3
PET 9/24/95	03	1+	93	7.7
PET 9/24/95	04	1+	94	7.7
PET 9/24/95	05	1+	101	10.4
PET 9/24/95	06	1+	105	11.8
PET 9/24/95	07	1+	105	10.9
PET 9/24/95	08	1+	105	11.1
PET 9/24/95	09	1+	106	12.0
PET 9/24/95	10	1+	110	12.8
PET 9/24/95	11	1+	110	13.4
PET 9/24/95	12	1+	110	13.3
PET 9/24/95	13	1+	110	13.6
PET 9/24/95	14	1+	110	12.1
PET 9/24/95	15	1+	111	13.8
PET 9/24/95	16	1+	112	13.2

Appendix C. Continued.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
PET 9/24/95	17	1+	113	14.4
PET 9/24/95	18	1+	115	14.2
PET 9/24/95	19	1+	115	13.8
PET 9/24/95	20	1+	116	13.9
PET 9/24/95	21	2+	142	30.9
PET 9/24/95	22	2+	145	31.6
PET 9/24/95	23	2+	145	34.2
PET 9/24/95	24	2+	147	33.6
PET 9/24/95	25	2+	149	37.2
PET 9/24/95	26	2+	150	34.4
PET 9/24/95	27	2+	150	34.8
PET 9/24/95	28	2+	152	41.3
PET 9/24/95	29	2+	152	34.5
PET 9/24/95	30	2+	153	35.0
PET 9/24/95	31	2+	153	34.4
PET 9/24/95	32	2+	154	37.3
PET 9/24/95	33	2+	154	42.4
PET 9/24/95	34	2+	155	37.8
PET 9/24/95	35	2+	155	38.4
PET 9/24/95	36	2+	157	44.6
PET 9/24/95	37	2+	157	44.4
PET 9/24/95	38	2+	158	44.3
PET 9/24/95	39	2+	158	44.8
PET 9/24/95	40	2+	158	42.8
PET 9/24/95	41	2+	158	43.9
PET 9/24/95	42	2+	159	44.1
PET 9/24/95	43	2+	159	39.7
PET 9/24/95	44	2+	159	41.1
PET 9/24/95	45	2+	160	44.2
PET 9/24/95	46	2+	160	41.9
PET 9/24/95	47	2+	160	38.4
PET 9/24/95	48	2+	161	46.1
PET 9/24/95	49	2+	161	45.5
PET 9/24/95	50	2+	161	54.1
PET 9/24/95	51	2+	161	48.9
PET 9/24/95	52	2+	161	44.6
PET 9/24/95	53	2+	161	44.2
PET 9/24/95	54	2+	161	44.9
PET 9/24/95	55	2+	162	45.5
PET 9/24/95	56	2+	162	45.5
PET 9/24/95	57	2+	162	47.2
PET 9/24/95	58	2+	162	45.3
PET 9/24/95	59	2+	163	43.3
PET 9/24/95	60	2+	163	47.9
PET 9/24/95	61	2+	164	48.2
PET 9/24/95	62	2+	165	49.6

Appendix C. Continued.

Lake/Trawl Date	Fish No.	Age	Fork Length (mm)	Weight (g)
PET 9/24/95	63	2+	165	48.7
PET 9/24/95	64	2+	166	47.6
PET 9/24/95	65	2+	167	50.8
PET 9/24/95	66	2+	167	51.2
PET 9/24/95	67	2+	167	49.9
PET 9/24/95	68	2+	168	53.5
PET 9/24/95	69	2+	170	58.0
PET 9/24/95	70	2+	170	48.1
PET 9/24/95	71	2+	170	54.2
PET 9/24/95	72	2+	170	49.4
PET 9/24/95	73	2+	171	51.9
PET 9/24/95	74	2+	172	54.2
PET 9/24/95	75	2+	173	58.7
PET 9/24/95	76	2+	173	54.2
PET 9/24/95	77	2+	173	61.5
PET 9/24/95	78	2+	173	54.3
PET 9/24/95	79	2+	174	63.9
PET 9/24/95	80	2+	174	58.2
PET 9/24/95	81	2+	178	59.9
PET 9/24/95	82	2+	179	61.2
PET 9/24/95	83	2+	180	61.4
PET 9/24/95	84	2+	183	69.8
PET 9/24/95	85	3+	205	100.7
PET 9/24/95	86	3+	207	94.0
PET 9/24/95	87	3+	217	115.7
STA 9/27/95	01	0+	32	0.3
STA 9/27/95	02	0+	36	0.4
STA 9/27/95	03	0+	45	0.9
STA 9/27/95	04	0+	46	0.9
STA 9/27/95	05	0+	73	3.9
STA 9/27/95	06	0+	78	4.6
STA 9/27/95	07	1+	100	10.2
STA 9/27/95	08	1+	151	39.8
STA 9/27/95	09	2+	187	61.6
STA 9/27/95	10	2+	190	67.7

[a] Captive broodstock program-produced juvenile.

Appendix D. Mean nuclear Sr/Ca ratios of sagittal otolith nuclei from Redfish Lake *O. nerka* with differing life histories.

Fish ID[a]	Nuclear Sr/Ca	Standard Deviation	Coefficient of Variation
FHC-1	0.00060	0.000068	0.11
FHC-2	0.00057	0.000114	0.20
FHC-3	0.00062	0.000095	0.15
FHC-4	0.00066	0.000083	0.13
FHC-5	0.00052	0.000121	0.23
FHC-6	0.00059	0.000076	0.13
FHC-7	0.00058	0.000108	0.19
FHC-8	0.00053	0.000098	0.19
FHC-9	0.00059	0.000116	0.20
FHC-10	0.00066	0.000210	0.32
FHC-11	0.00059	0.000103	0.17
FHC-12	0.00062	0.000095	0.15
FHC-13	0.00059	0.000055	0.09
FHC-14	0.00069	0.000063	0.09
FHC-15	0.00059	0.000069	0.12
FHC-16	0.00065	0.000088	0.13
FHC-17	0.00052	0.000076	0.15
FHC-18	0.00054	0.000136	0.25
FHC-19	0.00058	0.000079	0.14
FHC-20	0.00061	0.000112	0.18
BY94-1	0.0019	0.000124	0.07
BY94-2	0.0019	0.000109	0.06
BY94-3	0.0018	0.000198	0.11
BY94-4	0.0019	0.000084	0.05
BY94-5	0.0021	0.000146	0.07
BY94-6	0.0020	0.000114	0.06
BY94-7	0.0021	0.000214	0.10
BY94-8	0.0018	0.000136	0.08
BY94-9	0.0019	0.000130	0.07
BY94-10	0.0020	0.000075	0.04
BY94-11	0.0021	0.000055	0.03
BY94-12	0.0019	0.000115	0.06
BY94-13	0.0020	0.000113	0.06
BY94-14	0.0021	0.000094	0.04
BY94-15	0.0021	0.000152	0.07
BY94-16	0.0019	0.000083	0.04
BY94-17	0.0021	0.000142	0.07
BY94-18	0.0019	0.000133	0.07
BY94-19	0.0019	0.000139	0.07
BY94-20	0.0021	0.000078	0.04
BY94-21	0.0020	0.000086	0.04
BY94-22	0.0020	0.000069	0.04
BY94-23	0.0020	0.000155	0.08
BY94-24	0.0021	0.000101	0.05
BY94-25	0.0020	0.000035	0.02
BY94-26	0.0020	0.000136	0.07
BY94-27	0.0021	0.000059	0.03

Appendix D. Continued.

Fish ID[a]	Nuclear Sr/Ca	Standard Deviation	Coefficient of Variation
BY94-28	0.0020	0.000102	0.05
BY94-29	0.0019	0.000066	0.03
BY94-30	0.0021	0.000204	0.10
BY94-31	0.0020	0.000064	0.03
BY94-32	0.0020	0.000139	0.07
BY94-33	0.0020	0.000122	0.06
BY94-34	0.0019	0.000082	0.04
BY94-35	0.0020	0.000051	0.02
BY94-36	0.0019	0.000104	0.05
BY94-37	0.0019	0.000112	0.06
BY94-38	0.0019	0.000111	0.06
BY94-39	0.0018	0.000168	0.09
BY94-40	0.0018	0.000132	0.07
BY94-41	0.0019	0.000134	0.07
BY94-42	0.0020	0.000099	0.05
BY94-43	0.0020	0.000137	0.07
BY93-1	0.0019	0.000158	0.09
BY93-2	0.0016	0.000070	0.04
BY93-3	0.0017	0.000071	0.04
BY93-4	0.0016	0.000069	0.04
BY93-5	0.0016	0.000085	0.05
BY93-6	No Sample		
BY93-7	0.0016	0.000141	0.09
BY93-8	0.0017	0.000114	0.07
BY93-9	0.0017	0.000137	0.08
BY93-10	0.0017	0.000151	0.09
BY93-11	0.0016	0.000128	0.08
BY93-12	0.0016	0.000120	0.08
BY93-13	0.0016	0.000118	0.08
BY93-14	0.0017	0.000088	0.05
BY93-15	0.0010	0.000098	0.10
BY93-16	0.0017	0.000097	0.06
BY93-17	0.0015	0.000139	0.09
BY93-18	0.0016	0.000100	0.06
BY93-19	0.0015	0.000107	0.07
BY93-20	0.0016	0.000094	0.06
BY93-21	0.0014	0.000171	0.13
BY93-22	0.0016	0.000111	0.07

[a] FHC 1 - 20 are adult, male kokanee spawners removed from Fishhook Creek (primary kokanee spawning tributary of Redfish Lake) in 1995.

BY94 1 - 43 are first generation progeny of the one anadromous female sockeye salmon that returned to Redfish Lake Creek in 1994.

BY93 1 - 22 are first generation progeny of the two anadromous female sockeye salmon that returned to Redfish Lake Creek in 1993.

Submitted by:

Paul A. Kline
Senior Fishery Research Biologist

James A. Lamansky, Jr.
Fishery Technician

Approved by:

IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Chief
Bureau of Fisheries

Allan R. Van Vooren
Fisheries Research Manager